This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

+ *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.

+ *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.

+ *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.

+ *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at `http://books.google.com/`

GV341
.B82

GV341 .B82
A teachers' course in physical trai
Gutman Library AOV4402
3 2044 028 805 117

A TEACHERS' COURSE
IN
PHYSICAL TRAINING

BOWEN

HARVARD UNIVERSITY

VE RI
TAS

LIBRARY OF THE

GRADUATE SCHOOL
OF EDUCATION

HARVARD UNIVERSITY

VE RI TAS

LIBRARY OF THE

GRADUATE SCHOOL
OF EDUCATION

A TEACHERS' COURSE

IN

PHYSICAL TRAINING

A BRIEF STUDY OF THE FUNDAMENTAL PRINCIPLES OF GYMNASTIC TRAINING

DESIGNED FOR TEACHERS OF THE PUBLIC SCHOOLS

BY
WILBUR P. BOWEN,
DIRECTOR OF PHYSICAL TRAINING,
MICHIGAN STATE NORMAL COLLEGE.
1899.

ANN ARBOR:
GEORGE WAHR,
PUBLISHER.

HARVARD UNIVERSITY
GRADUATE SCHOOL OF EDUCATION
MONROE C. GUTMAN LIBRARY
JUNE 22, 1938

GV341
.B82

Copyright by George Wahr,
1899.

ANN ARBOR, MICH.

PREFACE.

The only excuse for the existence of this little volume is necessity. It has been the duty of the author, during the past four years, to give a ten weeks' course in the theory of Physical Training to meet the needs of students preparing to teach in the grades of the public schools. It is of course imperative that these prospective teachers be given as clear an insight as possible into the principles of Anatomy, Physiology, Hygiene, Gymnastic technique, and Pedagogy upon which the teaching of Physical Training depends. The attempt to have this knowledge acquired by reference to the standard works in these subjects,—a plan that is perfectly feasible in the case of students taking a more complete course,—has resulted in the use of a large amount of time that was comparatively unproductive, because the books that are reliable are very full and very technical in their discussions of these matters. The circumstances demand the use of a text, to be supplemented by lectures, demonstrations and recitations. Such a guide was not to be found in the market,—hence the necessity.

The student is warned against the thought that this course is an adequate preparation for special teachers of Physical Training. It is at most only a brief and superficial view of the field, in intent suggestive of lines of further study. Neither is it a course of practical work to be followed in the school room. It is rather a course of study designed to prepare the teacher to use more intelligently some of the many practical courses of work already on the market.

TABLE OF CONTENTS.

PART FIRST.—ANATOMY AND PHYSIOLOGY.

Chapter I.—The Neuro-Muscular System.

1. General view. 2. Structure of muscular system. 3. Structure of nervous system. 4. Structural relation of muscular and nervous systems. 5. The myograph. Nerve muscle preparations. 6. Properties of muscle and nerve. Methods of stimulation. 7. Fatigue of muscle. 8. Effect of changes of load, changes of strength of stimulus, changes in rapidity of stimulus. Tetanus. 9. The spinal cord and the spinal nerves. 10. Types of nerve-cells. Reflex paths. 11. Reflex movements. 12. The brain. The motor area. Voluntary paths. 13. Relation of voluntary and reflex movements. How a new movement is acquired. Habit. 14. Fatigue in voluntary and reflex movements. The ergograph. Chemical and microscopic investigations. 15. Influence of mental states upon muscular contraction. The knee-jerk experiment. 16. Time occupied in voluntary and reflex movements.

Chapter II.—The Vital Organs of the Body as Affected by Exercise.

17. General view. 18. The circulatory system. 19. The respiratory system. 20. Bodily temperature. 21. Bathing. 22. Exercise and development. 23. Exercise and digestion.

HARVARD UNIVERSITY

VE RI
TAS

LIBRARY OF THE

GRADUATE SCHOOL
OF EDUCATION

places they lie across one another in apparent confusion.

Heart fibers differ most noticeably from the voluntary in being composed of short cells joined end to end. They also have branches connecting the different fibers. Each cell contains a single large nucleus.

3. The nervous system consists of the *central* and *peripheral* portions. The central portion is further divided into the *brain*, *medulla*, and *spinal cord*, and the brain still further divided into *cerebrum*, *cerebellum*, and *basal ganglia*. The peripheral portion includes the *sympathetic system*, lying within the body cavity, and the *spinal* and *cranial nerves*,

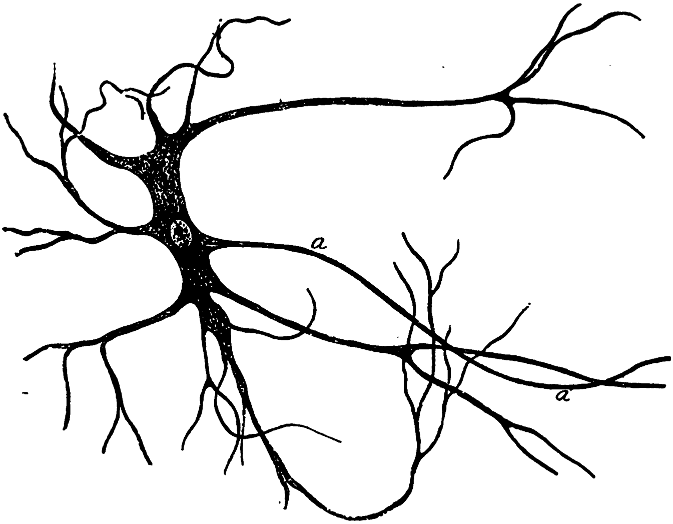

Fig. 5. A nerve cell. a, neuron. (From Howell.)

REFERENCES: *Connective tissue* and *muscle*,—Piersol, Klein, Stöhr, Landois and Stirling, Gray, Martin, Quain, Rettger.

NOTE.—Titles of books and initials of authors will be found in the Bibliography.

Unless reference to volume and page is given, consult index for the topic.

degenerates, while the part joined to the cell-body lives. The dead fiber is sometimes replaced by new tissue, the axis-cylinder growing out again from the end of the uninjured portion.

4. The muscular and nervous systems are closely related in structure as well as in function. Every muscle fiber, as far as is known, is joined to a nerve cell. In voluntary muscle, where the details of structure are most easily seen, the neurilemma of the connecting nerve-fiber is continuous with the sarcolemma of the muscle-fiber, and the axis-cylinder passes within. After entering the muscle-fiber the axis-cylinder terminates in a number of minute branches that spread out like the roots of a tree. In this way the gray tissue of the nerve-cell is brought into close proximity to the contractile tissue of the muscle-fiber. This particular form of nerve-ending, although very much like the endings in other parts, is called the *motor end-plate.* The terminations of fibers in other parts are usually called *end-brushes*, or *brush-endings.*

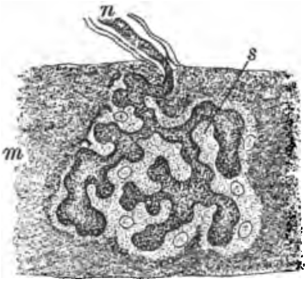

Fig. 7. Motor end-plate in muscle. m, contractile tissue; n, axis-cyilnder. (From Piersol.)

EXERCISES.

Make drawings from memory of (1) a fiber of voluntary muscle, (2) a fiber of involuntary muscle, (3) a fiber of

---

References: *Nerve-cells, nerve-fibers* and *neuroglia,*—Piersol, Klein, Stöhr, Landois and Stirling, Quain, Howell, Rettger.

References: *Nerve-endings in muscle,*—Piersol, Klein, Stöhr, Landois and Stirling, Quain, Rettger, Waller, Gray.

heart muscle, (4) a strand of white connective tissue fibers, (5) several yellow connective tissue fibers, (6) a nerve-cell, (7) a nerve-fiber, showing all the parts, (8) a motor end-plate in place, showing the manner of union of the nerve-fiber and muscle-fiber.

If a muscle-fiber one millimeter in length is able to contract to one-half its length, and to lift one gram,—(9) what weight can 50 such fibers lift, if connected end to end? (10) How far could they lift this weight? (11) How much could the same number of fibers lift if arranged to pull side by side, as in penniform muscles? (12) How far could they lift this weight?

5. Many functions and properties of muscle are studied by the use of an instrument called the *myograph.* The essential parts of this instrument are (1) a standard supporting a clamp for suspending a muscle, (2) a small scale-pan that can be attached by a hook to the other end of the muscle, and several metal weights of two or three grams each, (3) a light pointer connected with the moving end of the muscle, and hinged so as to swing in a vertical plane and magnify the movement made by the muscle, (4) a moving surface upon which the end of the pointer can record the movements. The most common recording instrument used in physiological work is the *kymograph,* which consists of a cylindrical drum revolved at a uniform rate by means of clock-work. A piece of paper with a glossy surface is drawn tightly around the drum and then coated with lamp-black over a flame. This takes an impression very readily, and the latter can be made permanent by dipping the paper in an emulsion of shellac.

The muscles of cold-blooded animals are used in laboratory experiments of this character, because they retain their vitality for a considerable time after removal from the body if suitable conditions of temperature and moisture are maintained. On account of the ease with which they can be captured and kept, frogs are commonly used. A frog is killed, the muscle of the calf of the leg is dissected out and placed on a plate containing a normal solution of common salt. A portion of the femur is left attached to the muscle, for attachment to the clamp mentioned above. In some experiments a portion of the nerve supplying the muscle is dissected out with it, care being taken to leave it uninjured. In this case we have what is called a *nerve-muscle preparation.* It should be borne in mind that such a

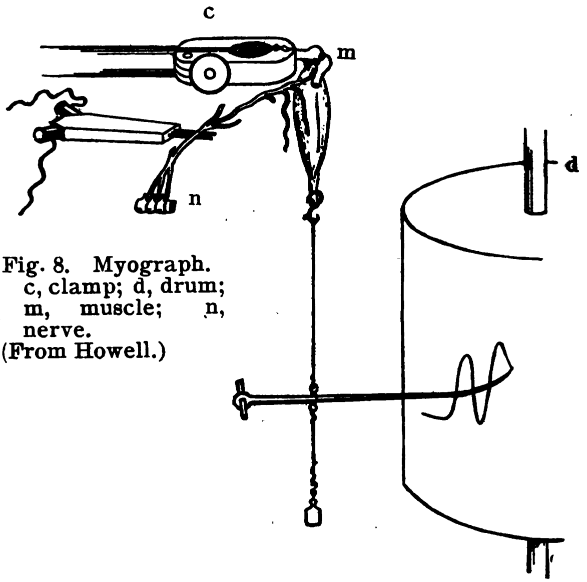

Fig. 8. Myograph. c, clamp; d, drum; m, muscle; n, nerve. (From Howell.)

REFERENCES: *Myograph, nerve-muscle preparation,*—Foster, Waller, Howell, Mills, Landois and Stirling, Rettger.

nerve is a bundle of nerve-fibers, some of which join the individual muscle-fibers of the muscle.

6. If we set up the myograph, with a nerve-muscle preparation in place, we can cause the muscle to contract by (1) pinching the muscle with fine forceps, piercing it with a needle, giving it a shock from an induction coil, or by applying a heated point or a drop of acid to its surface; or by (2) treating the nerve in the same way.

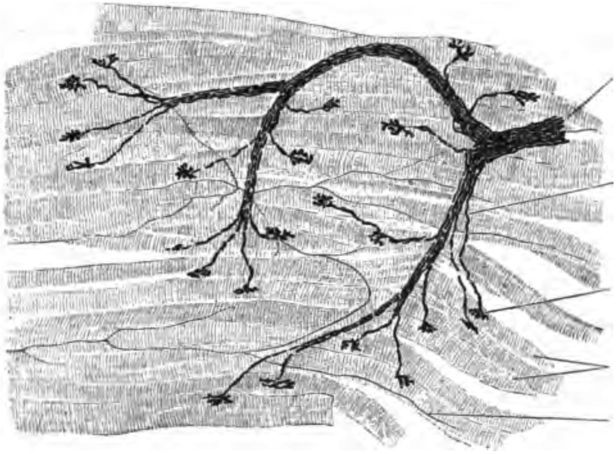

Fig. 9. Distribution of motor nerve-fibers in muscle. (From Landois.)

The experiments illustrate two fundamental properties of muscle: *irritability* and *contractility*. By irritability is meant the ability to be thrown inth a state of activity by a sudden change of outside conditions. When thus influenced a muscle is said to be *irritated*, *excited*, or *stimulated*. The exciting cause is called an *irritation* or *stimulus*. By contractility is meant the ability to change its form when irritated. The *contraction* of a muscle consists in the shortening and thickening of its individual muscle-fibers, by which the ends of the muscle are brought nearer together with considerable force. The lateral stretching of the connective tissue of the muscle makes the latter harden as it contracts. The return to the quiet condition is called *relaxation*. There is difference of opinion as to whether muscle-fibers change their size during contraction or not. Most of the authorities seem to favor the view that it is a change of form only.

The explanation of irritation and contraction involves microscopic and chemical experiments that cannot well be given in this course. In such experiments it is shown that muscular tissue, like other forms of living protoplasm, is at all times in a state of chemical activity. This chemical activity is a double process, including (1) a constructive process, in which tissue is built up and energy stored, and (2) a destructive process, in which tissue is torn down, energy set free, and *waste products* formed. In the constructive process there are prepared highly inflammable compounds of carbon, oxygen, etc. In the destructive changes these are burned. When the muscle is at rest, the energy set free by these changes is slight, and in the form of heat only; when the muscle is irritated, there occurs a very sudden and comparatively violent chemical activity that may be called an explosion, setting free a great amount of energy, a part of which is in the form of mechanical motion. The waste products are principally carbon dioxide and water, with minute quantities of organic poison.

No amount nor intensity of stimulation will cause the nerve to contract; in other words, gray nervous tissue is wholly lacking in contractility, but makes up for the lack by its remarkable irritability. It is of all tissues the most susceptible to outside influences. The explanation of the irritability of nervous tissue is the same as that of muscle tissue, but the amount of chemical change as shown by the quantity of waste products is much less in the case of the former. An excited condition is transmitted along a nerve-fiber at the rate of 30 meters per second. That which passes along the fiber is called an *impulse.* When an impulse passes down a fiber whose axis-cylinder enters a muscle-fiber, the end-plate is able to transmit the irritable condition to the muscle substance, and a contraction results. The contraction may be even greater than when the muscle is itself irritated.

The question may arise whether it is the muscle substance that is irritated when we pinch or shock a muscle, or whether it is the nerve-fibres scattered through it which are first influenced. This can be determined by the aid of a drug called *curari.* When curari is injected into the blood of a living animal it paralyzes all the motor end-plates, and thus cuts off all communication between the nervous and muscular systems. But the muscles of animals so treated, while powerless to move by their own volition, may be made to contract by external irritation as well as under normal conditions. There can be no doubt, then, that muscular tissue is itself irritable.

For the purposes of experiment, the current from an induction coil is better than the other forms of stimulation mentioned, because it is more easily and accurately applied, and also because it causes the greatest contraction of any with least injury to the tissues to which it is applied. A common companion piece of the myograph is therefore a battery connected to the primary circuit of an induction coil, with a key or other means of opening and closing at will, while the muscle or nerve is introduced between the terminals of the secondary circuit. Where a repeated stimulation at regular intervals is desired, a pendulum is often introduced into the primary circuit. Several devices are also used for the same purpose.

7. In order to study the effects of continuous exercise upon muscle, we stimulate by induction shocks of uniform strength at regular intervals of about one second, and observe the resulting tracing on the drum of the kymograph. Care must be taken that the stimulus is constant and that the muscle is kept moist with normal salt solution. The tracing, which is called the "curve" of the muscle, is a very accurate record, enabling us to notice very minute changes in the frequency, height, or character of the movements. We notice (1) the almost perfect regularity with which the muscle responds to the stimulus, and the uniform height of the contractions. After a short time there is seen (2) a gradual and uniform decrease in the height, indicating a corresponding loss of contractile power resulting from the work. Accompanying this it may be observed that the records of the individual contractions become broader at the top, showing that relaxation is slower. It may become so slow that the muscle does not have time to relax fully between the contractions. The height of the contractions keeps on diminishing until finally they cease entirely. The gradual loss of power which always follows work is called *fatigue*, while the final stage is known as *exhaustion.*

As to the causes of fatigue, a consideration of the chemical changes accompanying contraction would lead us to suppose that it is to be attributed either to (1) lack of

---

References: Foster, Waller, Rettger, Howell, Landois and Stirling.

oxygen, (2) lack of fuel, or (3) the presence of waste products. These are the common causes of insufficient combustion in a stove or furnace, and would naturally suggest themselves as the causes of insufficient combustion anywhere. Other experimental facts throw light on the question. If a muscle which has been fatigued to the point of exhaustion is left in place on the myograph for five minutes of rest, it is able to work again, and this can be repeated several times with the same muscle under favorable conditions. When this has failed to revive the muscle, placing it in a dish of normal salt solution for a few minutes will sometimes accomplish it again. Such recovery would scarcely be possible if the fatigue were due to depletion of the supply of fuel or oxygen. Chemical analysis shows that only a small part of these supplies is used up, even in the case of complete and final exhaustion. The fact that rinsing in salt and water aids so effectively in recovery from fatigue favors the view that the waste products play an important part. Carbon dioxide is readily soluble in water, favoring its ready removal by rinsing. Its presence is unfavorable to combustion, and it is capable, in sufficient quantities, of paralyzing nerves. A rested animal at once shows symptoms of fatigue when venous blood from a fatigued animal is injected into its veins. The ready recovery of the muscle by rest alone is probably due to the fact that only a small proportion of the fuel and oxygen stored up in the muscle is in the explosive form. The protoplasm carries on the constructive activity to keep pace with the destructive activity of contraction as nearly as possible, but falls behind when the work is continuous and rapid. When given a moment's time, it prepares more explosive material and is ready for work again. When the muscle is fatigued beyond recovery, it is probably because the protoplasm is too nearly dead to carry on its proper work. The cause of the slow relaxation accompanying fatigue has not been discovered.

8. If the intervals between successive stimulations of a muscle are several seconds in length, not only is the relaxation complete, but there is almost complete recovery from fatigue, so that the contractions are of practically the same height for some time. By making long intervals we are therefore enabled to eliminate the element of fatigue and study the effects of changing the load, the temperature, the strength of stimulus, etc.

If we begin with no weights in the scale-pan and add one during each interval, we obtain a record of changes in height of contraction due to change of load. We find that the muscle contracts highest when a small weight is used, then gradually diminishes until the load is reached that it is unable to lift. The work done in each case is found by multiplying the weight by the height. The muscle will be found to do the greatest amount of work neither with the smallest nor greatest load, but with somewhat more than half it can lift.

The strength of stimulus is varied either by varying the resistance in the primary circuit or by varying the distance between the primary and secondary coils. Beginning with a current too small to produce a contraction, we gradually increase it until the limit of our source is reached. The height of contraction increases with the increased stimulus until a certain point is reached, when it becomes

---

REFERENCES: Foster, Waller, Rettger, Howell, Landois and Stirling.

stationary, and no amount of increase in strength of current will make it contract higher. On the contrary, a stimulus stronger than is necessary makes relaxation slower,—a condition which, in the body, tends to stiffness and awkwardness of movement.

By gradually increasing the rapidity of stimulation a point is reached, when the intervals are about one-fifth of a second, where no relaxation occurs, the muscle remaining in a state of contraction until exhausted. This kind of stimulation is called *tetanic*, and the contracted condition is known as *tetanus*. The stimulus given to the muscles from the central nervous system is tetanic, the rate being about ten per second.

QUESTIONS AND EXERCISES.

(1) Make a diagram of the essential parts of the myograph. (2) Make a diagram of the apparatus used for electrical stimulation. (3) Make a drawing to show the change in a muscle's form during contraction. (4) Draw a muscle curve showing fatigue and rest. (5) Draw a muscle curve showing change due to increase of load. (6) Draw a muscle curve showing change due to increase of stimulating current. (7) Draw a muscle curve showing development of tetanus by increasing rapidity of stimulation. (8) Does the nerve impulse furnish power to the muscle, or merely serve as a signal? (9) What relation exists between the induction shock and the nerve-impulse? Are they the same? (10) What is the relation between the amount of materials used and the amount of waste products formed? (11) Will the combus-

---

References: Foster, Waller, Rettger, Howell, Landois and Stirling.

tion of the same amount of material give the same amount of energy at different times?

9. We have seen in the preceding experiments that a muscle, removed from the body and separated from the central nervous system, remains in a state of rest unless stimulated by some outside force. It has frequently been shown by cases of bodily injury and by experiments upon living animals that muscles whose nerves are severed no longer perform their normal function, but waste away, unless the nerve reunites. We are therefore justified in concluding that, normally, voluntary muscles do not act automatically nor by direct influence of the will, but only in response to impulses sent to them from the central nervous system. A search for the origin of these impulses requires a study of the structure of the spinal cord and the spinal nerves.

The spinal cord is a somewhat cylindrical column lodged in the spinal canal. It is composed of a vast number of nerve-cells (cell-bodies and processes), suspended in a net-work of connective tissues, the neuroglia. The cord is deeply cleft lengthwise by two fissures. the *anterior* and *posterior median fissures.* The anterior fissure is a true fissure, but the sides of the posterior fissures are held firmly together by connective tissue. The outer part of the cord is white, being composed of medullated fibers. The inner portion is gray, being composed of cell-bodies and non-medullated fibers. Cross sections of the cord show the gray matter to be arranged in a form roughly comparable to the letter H. The cross-bar of the H is called the *commissure,* and the four extremities the *cornua* or *horns* of the cord. The form and size of the horns vary somewhat in different parts of the cord.

Between each two vertebrae two nerves pass out from the cord, one on each side, called the spinal nerves. They divide and sub-divide, and are distributed to all parts of the body. Each spinal nerve leaves the cord by two roots,—one opposite the anterior horn called the *anterior root,* and one opposite the posterior horn called the *posterior root.* The two roots join to form the nerve just before they leave the spinal canal, and just before they join, the posterior root has a *ganglion* upon it, called the *posterior spinal root ganglion,* or simply the *spinal ganglion.*

Study of surgical cases and experiments upon animals have established the following facts as to the functions and relations of the spinal nerve roots:

(1) When the anterior root of a spinal nerve is divided, the part of the body to which the nerve is distributed suffers complete motor paralysis without loss of sensibility.

(2) When the posterior root of a spinal nerve is divided the part of the body to which the nerve is distributed suffers complete loss of sensibility without motor paralysis.

(3) When an anterior root is divided, the fibers separated from the cord soon degenerate.

(4) When a posterior root is divided, the fibers separated from the spinal ganglion soon degenerate.

QUESTIONS.—Reasoning from the above facts, (1) Which root contains the motor fibers? (2) Which contains the sensory fibers? (3) Where are the cell-bodies from which the motor fibers arise? (4) From which the sensory fibers arise? (5) Which way do impulses travel in the anterior root? (6) In the posterior root?

REFERENCES: Rettger, Waller, Howell, Martin, Landois and Stirling.

10. The natural conclusions from the above experimental facts are corroborated by microscopic study. Some of the fibers of the anterior root can be seen to arise from large cells in the anterior horn and to pass out through the white part of the cord into the nerve root. These cells are of a type that is very common in the spinal cord and are worthy of special notice. Each has one branch called the *axis-cylinder process* by some writers, and the *neuron* by others. Its office is to transmit impulses outward from the cell-body, and it is characterized by the irregular manner of its branching, when it is branched at all, and its enormous length, which may be nearly 100,000 times its diameter. These are the fibers that pass out through the anterior roots and spinal nerves to the muscle-fibers. They are usually medullated. Besides the one transmitting branch, each cell may have an indefinite number of shorter and regularly branching processes that are non-medullated. They are called *dendrites* or *dendrons.* Their office is to receive impressions and transmit impulses *to* the cell-body. They extend out into the gray portion of the cord in various directions, and thus greatly increase the range of territory from which the cell may be influenced.

The fibers of the posterior root can be seen to arise from the cell-bodies of the spinal ganglion. These cells are of another type, having two neurons and no dendrons. One neuron extends out through the nerve to some point in the body, where it terminates in an *end-organ* whose office is to receive impressions. The other neuron passes into the cord, where it divides into an ascending and a descending branch. These two branches extend in a vertical direction in the white part of the cord, and at frequent intervals give off horizontal branches which enter the gray portion and terminate in brush-like endings among the cell-bodies and dendrons. The horizontal branches are known as *collaterals.* The terminal end-brushes are transmitting organs. When an impulse passes along a collateral to the end-brush, the excited condition of the latter causes a similar excitement of the cell-bodies and dendrons that are near enough, and when a motor-cell is thus influenced, an impulse is sent to a muscle-fiber, and a contraction occurs. By means of this influence which sensory nerve-cells are able to exert upon motor nerve-cells, the irritation of sensory nerve-endings often produces muscular movements without the intervention of mental processes. Such movements are called *reflex movements.*

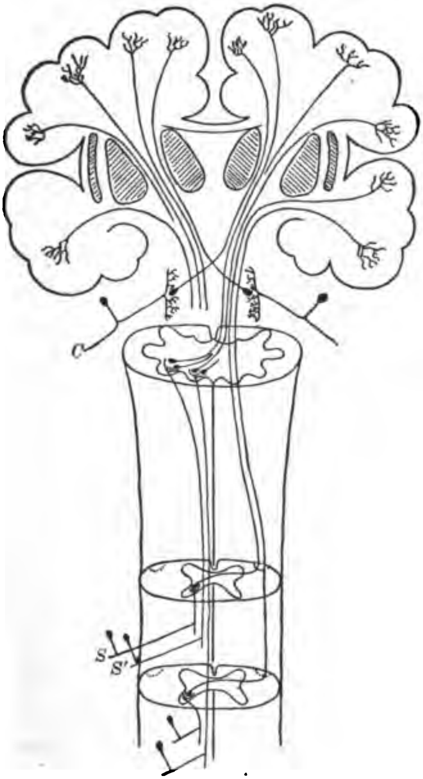

Fig. 10. Sensory paths in the central nervous system. (From Howell.)

Besides the two kinds of nerve-cells just described, two other kinds of cells are important in reflex movements. They are usually named *tract* cells and *commissural* cells. They are found in the gray portion of the cord, and are of the same form. They are like the motor-cells in having one neuron and an indefinite number of dendrons, but the form of the neuron is like that of those sensory neurons that pass into the cord. The neuron passes outward as far as the white part of the cord, where it divides into an ascending and a descending branch, and these give off collaterals which terminate in exactly the same manner as those of sensory neurons. The neurons of tract cells pass into the white matter of the same side of the cord, while those of the commissural cells pass through the commissure to the opposite side of the cord, and end there in a similar way. Tract and commissural cells are smaller than motor cells, and differ from each other only in the place to which the neuron is distributed. The cord contains other types of nerve-cells, which the brevity of this course does not permit us to study.

On account of the vast number of fibers that are massed together in the cord, crossing each other in all directions, the tracing of any particular fiber for a considerable distance would be altogether impossible if it were not for ingenious devices used in the preparation of the tissue for microscopic study. In order to trace the fibers from a cell in the spinal ganglion, for instance, a posterior root is partly severed between the ganglion and the cord in a living animal. After keeping the animal as well as possible until time enough has elapsed for the cut fibers to to degenerate, the animal is killed, its central nervous system is removed, hardened, cut into thin sections, mounted upon microscope slides, and stained. A stain is used that has the peculiarity of coloring the dead fibers in sharp contrast with the living. This enables the observer to distinguish the group of cut fibers readily, to follow it through different sections to its termination, and, in favorable cases, to see where and in what manner the individual fibers end. The description given above of the branching, distribution, and ending of sensory fibers has been largely worked out by specialists using this and similar methods. It has been found by such investigation that the ascending branches of the sensory neurons of spinal ganglion cells sometimes extend upward as far as a certain ganglion in the medulla, but never higher.

QUESTIONS: (1) When a sensory end-organ in the skin is irritated, what route must the resulting impulse travel to reach the spinal cord? (2) Where is the first cell-body that such an impulse will reach? (3) How far can it travel upon the nervous tissue of this one nerve-cell? (4) How many possible routes are there over which it may enter the gray portion of the cord? (5) How many nerve-cells must be traversed by an impulse from the skin before it can stimulate a muscle? (6) How many muscle-fibers will contract when a motor cell in the cord is stimulated? (7) What effect has the branching of sensory neurons in the cord upon the range over which a sensory impulse may exert an influence? (8) What effect has the presence of tract cells upon this range of influence? (9) What effect has the presence of commissural cells? (10) What is the effect of these conditions upon the number of muscle-fibers that will be stimulated because of the irritation of a sensory ending? (11) How many of the possible routes open to an impulse are probably followed in a given case? (12) What will the intensity of the irritation have to do with this? (13) What is the effect of the intensity of the impulse upon the range of influence of a brush-ending? (14) What is the effect of the intensity of the sensory impulse upon the force of the muscular contraction?

11. A frog whose brain has been removed will remain perfectly motionless until it dies, unless it receives some outward stimulation. If some point on the skin is irritated it will move. If the irritation is intense enough, it will jump. If food is placed in its mouth, it will swallow. If suspended from a hook and the foot pinched with a pair of forceps, the leg will be drawn up. If held tightly, so as to prevent this, the other leg will kick to drive off the intruder. If a bit of paper wet with acid is placed upon the animal's back, it will be kicked off, if the feet can possibly reach it. The brainless frog is a reflex machine, responding readily to sensory stimuli by appropriate movements. The character of the movements is not different from that of reflex movements which we constantly observe in ourselves and other persons, but they serve as more vivid examples because of the absence of voluntary control and because reflex movements are intensified by removal of the brain. The following general principles may be stated:

(1) The irritation of sensory nerve-endings, in a living animal, causes reflex movement, if the irritation has sufficient intensity. Such a stimulus may, in some cases, cause an interruption of movements taking place at the time, as when a touch or sound startles one who is busily working, or the reflex that tends to occur may be prevented by the will, as when one resists a tendency to dodge,—but these exceptions do not affect the truth of the general principle. One has but to watch himself closely for ten minutes, or observe a class of children in the school room, to realize how exceedingly numerous are these reflexes.

REFERENCES: Howell, Rettger, Klein, Stöhr, Landois and Stirling.

(2) The area of muscular action is not limited to the area of stimulation, and may even be far from it. The extent of the area of movement varies with the intensity of the stimulus. A mild irritation, whether of a large or small area, causes a slight movement. A very intense irritation, over an area no larger than a pin point, may cause a contraction of nearly all the muscles of the body. The spreading of the nerve impulses in such a manner can be accounted for by the branching of sensory and motor neurons, by the action of tract and commissural cells, and by the large number of dendrons that may lie within range of the influence of each brush-ending.

(3) Continuation of the stimulus increases the range and intensity of reflex movements. A single induction shock will scarcely cause a movement where a continuous application of milder shocks will produce a violent contraction. A fly walking upon a sleeping person's hand may not provoke a moment unless it stays for several seconds but after a time it is sure to cause a reflex. This is spoken of as the "cumulative effect" of continued stimulation.

(4) Reflex movements are not simple contractions of the muscles, such as are produced by irritating a bundle of motor nerve-fibers, but complex *co-ordinated* movements, suited to the accomplishment of some purpose bearing a relation to the stimulus. In fact, the most perfectly co-ordinated movements that we make are reflex. There are two classes of reflex movements, the natural or inherited reflexes and the acquired movements. The former include such movements as breathing, coughing, swallowing, laughing, etc., movements that are performed perfectly by young

---

REFERENCES: Foster, Waller, Howell, Landois and Stirling.

and old alike. The other and larger class includes walking, running, throwing, writing, etc., movements that are learned, through the agencies of volition, habit, etc., by a process of education described in a later paragraph.

12. The Brain includes the portions of the central nervous system located in the cranial cavity. Its principal divisions are the cerebrum, the cerebellum, the basal ganglia, and the medulla. The cerebrum and cerebellum have upon the surface a layer of gray nervous tissues, the *cortex.* Inside of this are medullated fibers. At the base of the brain several large masses of gray matter are found, the *basal ganglia.* The medulla contains fibers and ganglia arranged in constantly changing order as you pass downward.

The cortex of the cerebrum is the seat of consciousness and of voluntary control of the muscles. A certain area of the cortex of the top and sides of the cerebrum is called the *motor area.* The name has been given to it because of the discovery of the following facts:

(1) Disease of injury of any part of the motor area causes disturbance or entire loss of control of the corresponding muscles.

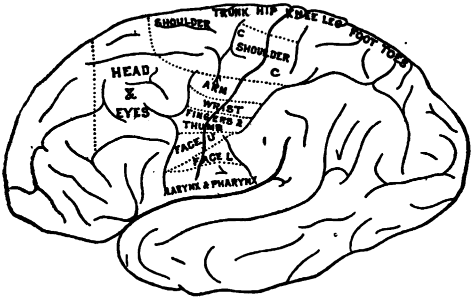

Fig. 10. (Motor areas of cerebral cortex.)
(From Howell.)

(2) Direct stimulation of any part of the motor area by induction shocks causes movement of the corresponding muscles.

(3) Removal or mutilation of any part of the motor

area soon causes degeneration of a bundle of fibers passing down through the medulla and cord and ending at the level where the spinal nerves pass out to supply the corresponding muscles.

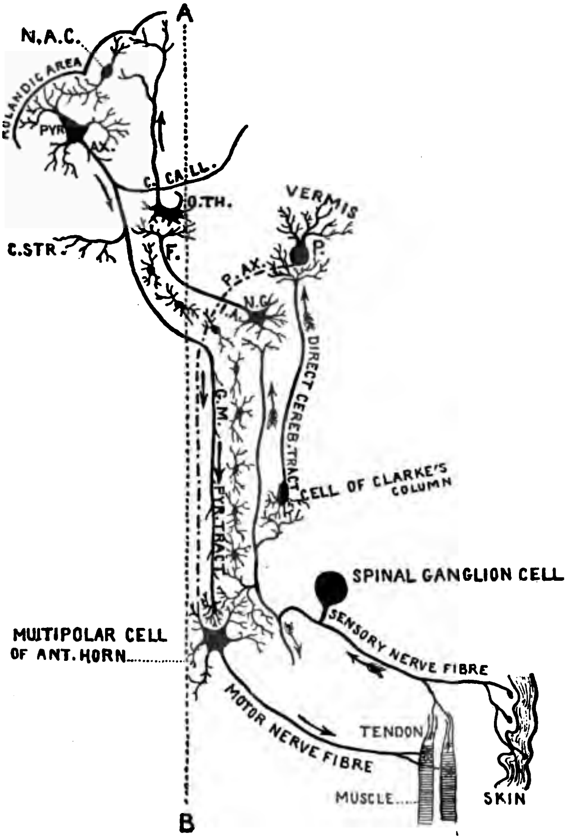

Fig. 12. Diagram to represent the paths of impulses in voluntary movement. (From Klein.)

By experiments along these lines the motor area has been mapped out into divisions corresponding to all the principal groups of muscles.

In the case of a voluntary movement, the impulse passing upward from the spinal ganglion cell follows the ascending branch up to the medulla. The excitement of the terminal brush causes an excitement in the surrounding cells and dendrons, and impulses pass up their neurons toward the cortex. These fibers cross to the opposite side and conduct the impulses to the cortex of the cerebrum, where they may give rise to a sensation. By means of the *association* fibers joining different parts of the cortex, the stimulaxion reaches cells of the motor area. These cells send impulses down their neurons through the medulla, crossing over, down through the cord to the proper level, where they turn into the gray matter of the anterior horn. By means of brush-endings there now occurs a stimulation of the same group of motor cells that have been referred to in our study of reflex movements, and contraction results.

QUESTIONS:—(1) How many different nerve-cells must be traversed by a sensory impulse before reaching the cerebral cortex? (2) How many must be traversed by a motor impulse from the cortex before reaching the muscle-fibers? (3) In what part of the entire route may other kinds of cells be involved? (4) What is the difference between voluntary and reflex movements as to their cause or origin?

13. All acquired bodily movements have a history including two stages, the voluntary and the reflex. The voluntary stage is characterized by a concentration of

---

REFERENCES: Howell, Waller, Foster, Landois and Stirling, Rettger.

attention upon the movement, which is imperfect, awkward, and quickly productive of fatigue. A mental process intervenes between the sensory and motor impulses. Just how we are able to control the movements cannot be explained, farther than to say that through the agency of the motor portion of the brain we are able to suppress a movement that tends to occur in response to a stimulus, or to *reenforce* or intensify it. Entire or partial suppression of a movement is called *inhibition.* Another important principle involved here is habit. Habit is an internal principle, inherent in living matter, because of which we do more easily what has been done before. In the reflex stage the movement is made without effort of attention, and at the same time more easily, gracefully and accurately.

The first step in the process of learning a new movement is to get a clear idea of what is to be done. This idea may be acquired in several ways, but the most practical and efficient of all is by seeing the movement performed and at the same time having its essential features and peculiar difficulties pointed out.

Next, an attempt is made to execute the movement. This attempt is more or less vague and indefinite, depending upon how much likeness exists between the movement and something done before. If the new movement is totally unlike anything the person has done, the attempt is a "leap in the dark." The first attempt is rarely, if ever, successful.

Having made a movement, habit leads us to make the same again. But we see that it is not correct, and so we must suppress it, in part at least. Comparing the faulty movement with the one given, we are able to make a more definite attempt next time. We continue in this manner, making wrong movements, comparing each with the pattern, and trying to suppress the incorrect parts, until finally, partly by chance, the movement is made correctly in all essential details.

From this point habit is given full sway, and repeated practice soon makes the movement reflex. The paths of the impulses become established, and the stimulus gives rise to the movement regularly, without the intervention of mental processes. The attention may now be given to other movements, which may be combined with this if desired. The ability of the voluntary centers to give over the co-ordination of acquired movements to the reflex centers of the spinal cord is the basis of all human skill. The almost infinite complexity and marvelous accuracy of which the neuro-muscular mechanism is capable could not exist but for the provision of nature which rewards the learner of every new movement by enabling him to perform it as a direct reflex.

14. The fatigue accompanying voluntary and reflex movements has been studied by microscopic and chemical methods and by the *ergograph*. The ergograph is an instrument for recording the movements of the middle finger, which is flexed and extended voluntarily at regular intervals, lifting a weight of from two to ten pounds. It consists of (1) a clamp or other device for holding the arm and hand firmly, (2) a cord passing over a pulley and connecting the finger with the weight, (3) a pointer for recording, connected to the finger by another cord, (4) a recording surface, usually a kymograph. The weight is lifted as high as possible at every contraction, and the work is continued until the weight can no longer be lifted.

REFERENCES: Foster, Waller, Howell, Landois and Stirling.

The curve thus obtained has irregularities of two kinds. There is a small irregularity in the heights of adjacent contractions, giving the appearance of a partly rythmical rise and fall, and a more general irregularity in the form of the entire curve, which seldom approaches anywhere near a straight line, and differs remarkably in the cases of different individuals. Since the curve of muscle, as taken with the myograph, has no irregularities, these must be attributed to the nervous mechanism involved in the ergograph work. Lack of uniformity in height of contraction indicates lack of uniformity in the strength of stimuli received by the muscles.

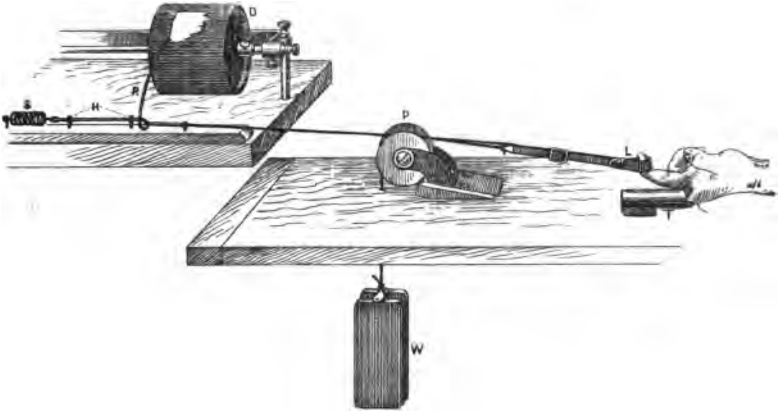

Fig. 13. Ergograph. D, drum of kymograph; L, loop to hold finger; P, pulley; W, weight; R, recording pointer; H, supports in which rod can slide; S, spring.

The principal muscles involved in this experiment are in the front part of the forearm. By using a strong current these muscles can be made to contract by stimulation with induction shocks, so as to lift the weight of the ergograph. If the neuro-muscular mechanism of the finger is fatigued to exhaustion upon the ergograph, and then, as soon as the voluntary effort is discontinued, we begin stimulating the muscles by electricity, the weight will be lifted almost as high as when the muscle was rested. What is still more remarkable, if we continue the electric stimulation at regular intervals for a few moments and then resume the voluntary effort to lift the weight, the fatigue is considerably relieved, and the weight is lifted quite easily to nearly the full height. This proves conclusively that it is not fatigue of the contractile tissue that compels rest from voluntary exercise; the most extreme fatigue is in some other part.

Microscopic and chemical examination of nerve-fibers fails to discover any change that can be attributed to fatigue. These fibers are so minute that it may not be safe to accept this as conclusive, but a certain myograph experiment throws light on the case. If a nerve-muscle preparation is stimulated by induction shocks until partially fatigued, and then, without stopping the stimulation, the nerve, where it enters the muscle, is surrounded with a bit of cotton saturated with carbon dioxide solution, the muscle soon stops contracting, because the nerve-impulse is not able to pass the point affected by the solution. The purpose of this is to rest the muscle while continuing to stimulate the nerve. After the stimulation has been kept up for half an hour or more,—long enough to exhaust the muscle three or four times,—the cotton is removed. The muscle soon begins to contract, and there is no indication of fatigue due to the continued activity of the nerve.

Chemical analysis of the brains and spinal cords of fatigued animals discovers carbon dioxide in considerable quantities, but not so much as is found in the muscle tissue of the same animals. Microscopic examination of the cell-bodies shows that the nuclei become shrunken and of different color in case of extreme fatigue.

Other investigations, microscopic, chemical, and physiological, have been made to determine the causes of voluntary fatigue, and the views of physiologists on the question may be summarized as follows:

At the beginning of bodily exercise, the stimulus needed is so slight that the work of the nervous mechanism is small in comparison with the work of the muscles. As soon as waste products form faster than the blood removes them, they collect in the muscle-fibers and begin to exert a paralyzing influence on the end-plates. This condition of the end-plates necessitates stronger impulses from the cell-bodies in the spinal cord. The continuation of this process throws more and more work on the nerve-cells and less and less on the muscles. Finally, as we approach exhaustion, the nervous system is doing all the work it can do, while the muscles are shielded from extreme fatigue by the paralyzing effect of carbon-dioxide upon the end-plates, which prevents the stimulation from passing.

15. The irregular form of the ergograph curve is partly due to mental characteristics of the individual and is partly the effect of outward conditions. The general health and strength of the muscles and the nervous system will determine *how soon* fatigue will become exhausting, but the general form of the curve, indicating the degree of fatigue at the various stages of the work, is determined by the temperament and character of the individual. Some are able to lift the weight to almost the full height as long as their power lasts, but give out completely when the curve begins

---

REFERENCES: Howell, Mosso, Foster, Waller, Landois and Stirling, Rettger.

to fall. Others can maintain the full height but a short time, but are able to continue the work for hundreds of contractions after the curve has diminished to half or one-third of its full height.

In order to secure uniform rhythm, the contractions are usually made to correspond to the beat of a pendulum or metronome placed in sight or hearing of the one at work. This gives an external sensory stimulus that is perfectly regular in its intensity, but the attention given to it will vary, on account of distracting occurrences, causing the slight irregularities before mentioned. It is also likely that changes of mental states gives similar effect. An encouraging word heightens the contractions for a moment.

The influence of mental states upon the intensity of muscular contraction is illustrated in the phenomenon known as knee jerk. If the tendon connecting the patella with the tibia is struck, while the knee is at a right angle and hanging freely, the extensor muscles will contract. This was formerly called a "tendon reflex," but is now considered a direct response of the muscle to the jerk given its tendon by the blow. Connecting the foot with the recording part of the ergograph we are able to register the amount of movement made. (A small hammer, swung on a pivot, is usen to give a uniform stroke at regular intervals.) The experiment shows a remarkable influence of mental conditions upon the muscles. If the person is undisturbed and tries to go to sleep, the knee-jerk almost ceases. A sudden noise of any kind causes a large movement. Telling him an exciting story results in large movements as long as the excitement lasts. Suddenly telling him some startling news causes a movement ten times as large as the preceeding. The common explanation of this is that the muscles, as well as the nervous system, are constantly under influence of what is passing in the mind. Some diseases of the nervous system increase this influence. Others destroy it entirely. The effect upon the athlete of the excitement of the contest and the applause of his fellows is more far-reaching than he supposes. The teacher of physical training should realize thoroughly how much the intensity of work depends upon the mental state of the worker.

Questions and Exercises:—(1) Draw a diagram showing the essential parts of the ergograph. (2) Make a drawing to show the characteristic difference between the curves of the myograph and the ergograph. (3) Which is more educational, the work done by the nervous system in learning new movements or in ergograph work ? Which is most exhausting? (4) What serves as an outward stimulus in gymnastic exercises in class? In a ball game? In walking? (5) How can the teacher vary the intensity of the work of the class?

16. When a movement is made in response to a stimulus or signal, a certain amount of time intervenes between the signal and the response. A part of this is used in the transmission of nervous impulses, and a part in the mental processes, in case of voluntary movement. When thought, or memory, or judgment is involved, more time is used. A convenient and accurate method of measuring the time used in all these mental and physiological processes is by use of a tuning-fork of known rate which is made to record its vibrations upon the moving drum of the kymograph along with the record of the movement. An electric time marker for registering the exact time of the stimulus, the

---

References; Howell, Mosso, Foster, Waller, Landois and Stirling.

pointer for recording the movement, and the pointer attached to the tuning-fork are all made to touch the drum in a vertical line. Whatever time intervenes between the signal and the response will be measured by the recorded vibrations of the fork. By experiments of this kind it has been found that muscle has a "latent period" of about .01 sec., that its contraction occupies about .04 sec., that impulses are transmitted along nerve-fibers at the rate of 30 meters per second; that the time occupied in a reflex movement, while varying considerably for different persons and under various conditions, averages about .06 sec.; and that the time for voluntary movements may be anything from .05 sec. to an indefinite length of time, depending upon how difficult are the problems of judgment and choice involved and also upon the individual.

REFERENCES: Howell, Landois and Stirling, Foster, Waller.

CHAPTER II.

THE VITAL ORGANS OF THE BODY, AS AFFECTED BY EXERCISE.

17. The neuro-muscular system is generally understood to include only the tissues and organs considered in the preceding chapter. The circulatory, respiratory, and digestive systems are, strictly speaking, also neuro-muscular systems, since their functions involve the actions of muscles, which are controlled by the nervous system. The movements belong to the class of natural or inherited reflexes, and, with the exception of breathing, are not subject to the influence of the will. The nerve-cells whose fibers pass to these muscles are situated in the medulla. The group of cells controlling a certain organ or function is called the *center* for that organ or function. The cells composing these centers, lying within the range of influence of brush-endings of fibers from the spinal ganglia and from the brain, are subject to the influence of mental states and of various kinds of sensory stimuli. Most of the nerve-fibers are non-medullated.

18. The circulatory system includes the *heart*, *arteries*, *capillaries*, and *veins*.

The function of the heart is to propel the blood; of the arteries, to distribute it to the tissues; of the capillaries, to bring it into intimate relation to the tissues; of the veins, to collect and return it to the heart. The circulatory system in man is a double system, having one complete circuit to the lungs and another to the body. The larger arterial trunks convey the blood to various parts of the body, where they give off branches which enter the bones, muscles, and other organs. The arteries entering a muscle pass through the sheath and between the bundles, sending smaller branches into the bundles. Within the bundles of fibers the small arteries, called *arterioles*, divide into the still smaller capillaries, which surround each fiber with a network of connecting tubes. These do not penetrate the muscle-fibers nor open into the spaces between them. Finally the capillaries unite to form the veins, which pass back to the heart by a course similar to that of the arteries. The distribution of blood to the lungs and other organs is very similar.

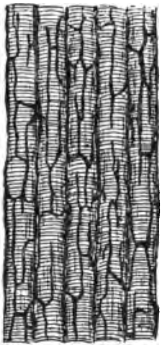

Fig. 14. Voluntary muscle fibers, injected to show the capilliares. (From Piersol.)

The heart is a hollow organ with muscular walls. When the walls contract the cavity is made smaller, and this forces the blood out. Valves allow the blood to pass out only to the arteries, and to enter only from the veins. It is a double organ, the right half sending blood to the lungs and the left half to the body. The upper chambers, or *auricles*, receive the blood from the veins and empty it into the chambers below, the *ventricles*. The latter, having much the heavier work to do, have their walls developed to a greater thickness. The left side of the heart is for the same reason stronger than the right.

Heart muscle differs from voluntary muscle in function as well as in structure. A frog's heart, removed from the body and severed from all nervous connections, will beat for some time in regular rythm, if suitable conditions are provided as to temperature and moisture. A small strip cut from a turtle's heart will beat in like manner. The hearts of birds and mammals are not so tenacious of life, but they can be made to beat for a short time after separation from the nervous ssytem. This automatic contraction at regular intervals is peculiar to the heart muscle, and seems to be a characteristic of the muscle substance itself, although there are ganglia within the heart.

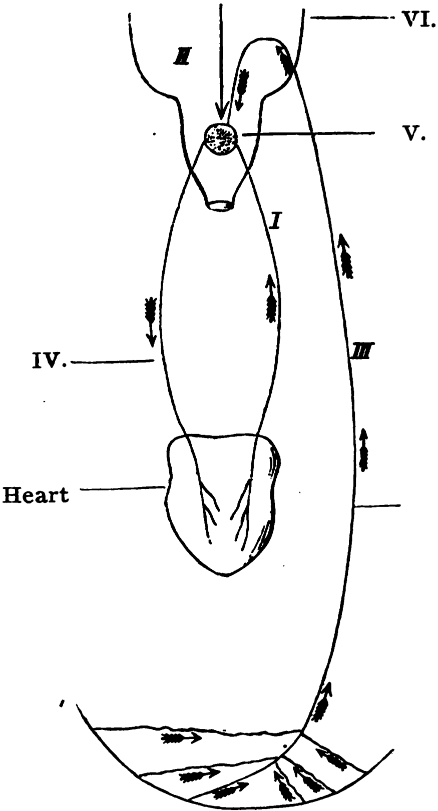

Fig 15. Diagram of nervous mechanism of cardiac inhibition. I, sensory fiber from heart; II, fiber from cerebrum; III, sensory fiber from the body; IV, inhibitory fiber to heart: V, inhibitory center; VI, brain. (From Mills' Animal Physiology.)

The strength and speed of the heart's contractions are controlled from two centers in the medulla, called the *cardiac inhibitory* and the *cardiac accelerator* centers. If the neurons from the inhibitory center are severed, the beat at once becomes more rapid. When they are stimulated by induction shocks, the beat becomes slower, and a strong stimulus will stop it for some moments. If the neurons from the accelerator centers are cut, no immediate effect is produced, but stimulation causes increased heart action. The commonly accepted explanation is that the inhibitory center is constantly sending impulses that inhibit the action of the heart, while the accelerator center acts only when need of increased action occurs. Through these agencies the heart's action is lessened in certain cases, as in loss of blood, severe injury or pain, and some emotions, and increased in others, such as the presence of an unusual amount of oxygen in the lungs or of waste products in the tissues, excitement, etc.

The arteries are cylindrical tubes whose walls are composed of three layers. The outer layer is elastic connective tissue. The middle layer, which is the thickest of the three, consists of fibers arranged in circular form, a part of them being elastic connective tissue and a part involuntary muscle.fibers. The inner layer is a soft membrane, which is continued into the capillaries, where the other layers are lacking-

If the arterial walls were rigid, the sudden increase of pressure produced by contractions of the left ventricle would be transmitted through the whole length of the tubes, and the soft, delicate walls of the capillaries would be in danger of rupture from the violence of these waves. The elastic walls of the arteries yield at each beat and then shrink more slowly to their former size, thus softening the force of the waves and changing the current gradually into a more constant stream. The sudden enlargement of an artery at the time of these waves is called the *pulse*, and furnishes a convenient means of investigating the character of the blood flow. The pulse may be felt wherever a large artery is near the surface.

A record of the pulse may be made upon the drum of the kymograph by means of two *tambours*, one for receiving and one for recording. The tambour is a shallow disk with the concave side covered with a piece of sheet rubber, drawn tight and fastened around the margin with a thread.

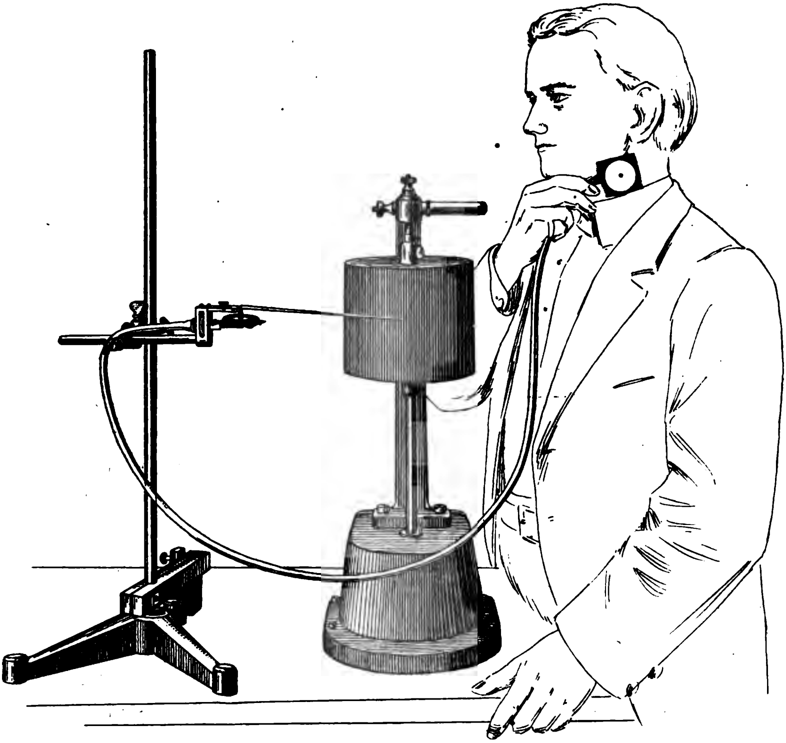

Fig. 16. Apparatus for recording pulse.

A small tube opens into the interior. By means of this tube the tambour is connected with a piece of rubber tubing which joins the other tambour in the same manner. The air chambers of the two tambours are thus put into free communication, and any pressure upon the face of one will cause a corresponding enlargement of the other. One of the tambours is applied to the skin over the artery. The other is arranged so as to move a pointer which writes on the drum. The best results are obtained from the carotid artery, in the neck. The instrument records the rate and character of the heart's beat, and shows also any changes in the strength, speed, or character of the beat resulting from exercise or other influences.

The friction between the blood and the walls of the tubes is considerable, increasing as they become smaller, which requires a correspondingly greater force from the heart to send the blood along. The pressure of blood in the larger arteries is sufficient, in case of a small opening through the wall, to cause the blood to be thrown several inches. The average pressure in the aorta in man is estimated at three or four pounds to the square inch. It varies with the action of the heart, increasing as the heart's beat is stronger and faster. The converse is necessarily true,—the greater the blood pressure, the greater the work required to propel the blood. A great increase in blood pressure results in a stimulation of the cardiac inhibitory center, thus checking the action of the heart.

The function of the muscular fibers in the arterial walls is to control the size of the arteries. They are supplied with nerve-fibers from the *vaso-motor* center, which is situated in the medulla. Through its influence the muscle-fibers are kept in a state of partial or *tonic* contraction. By changing the amount of constriction of these fibers throughout the whole arterial system, the blood pressure is controlled. For example, a bundle of nerve-fibers, called the *depressor fibers,* pass from the heart to the vaso-motor center. When the heart is injured or overworked, these fibers carry impulses which act upon the center, causing relaxation of the arterial walls and consequent reduction of blood pressure. Again, the vaso-motor mechanism is the means of changing the distribution of blood to different parts of the body. Change in the heart action can change the amount of blood sent to the body in a given time, but this change affects all parts alike. When some parts need more blood than others, the distribution is controlled by the vaso-motor center. In response to sensory stimuli acting upon the center the fibers in regions needing a greater blood supply are relaxed, while those in other parts are correspondingly contracted. Thus, when food is introduced into the digestive tract, impulses go the vaso-motor center and more blood is sent there. The same is the case when waste products are formed in the brain or in the muscles. Other cases of vaso-motor action will be mentioned later.

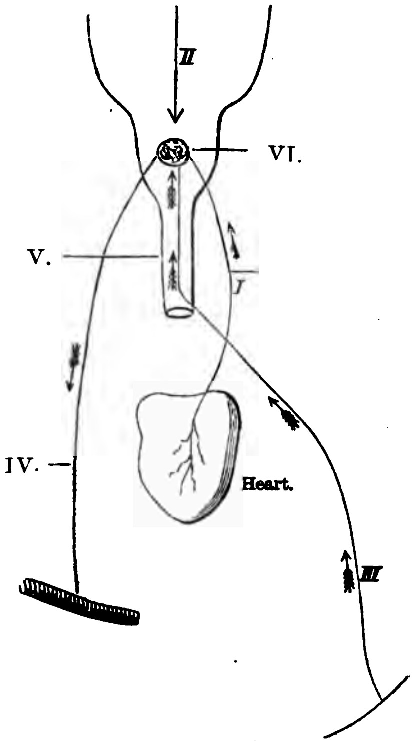

Fig. 17. Diagram of vaso-motor mechanism. I, sensory fiber from heart. II, fiber from brain. III, fiber from body. IV, fiber to muscle in walls of blood vessels. V, spinal cord. VI, vaso-motor center. (From Mills.)

The circulation in the veins, while primarily caused by the action of the heart, is materially assisted by (1) bodily movements of a rythmical character and by (2) breathing. These two agencies act directly in a mechanical way upon the circulation, and not, like the other influences mentioned, through the nervous system. The same effect is produced at the same time upon the circulation in the *lymphatic* vessels. The effect of rythmical exercises is due to the easy compressibility of the veins and lymphatics and the presence of valves. When the portion of a vein between two valves is pressed between contracting muscles, the blood contained in it is squeezed out, in a direction toward the heart. When the pressure is removed, it is filled again from the opposite direction. It will be seen that this is the identical action of a syringe pump,—indeed, the same as that of the heart itself, except that the pressure is from without. The value of *passive movements* and *massage* is largely dependent upon this effect. The influence of breathing upon the circulation in veins and lymphatics is due to the great reduction of pressure in the chest when it expands, causing a suction, which cannot act upon the arteries, because of the valves at the beginning of the aorta. The fluid in the veins and lymphatics is drawn toward the heart, and, when the chest falls in expiration, it cannot return because of the valves.

REFERENCES.—Rettger, Waller, Foster, Howell, Landois and Stirling.

QUESTIONS.—(1) How can you explain the rythmical character of the heart's beat? (2) What is the particular need in case of exercise than calls for immediate increase of heart action? (3) In exercise, what will determine the amount of increase of heart action? Why does running ordinarily increase the heart rate more than club-swinging?

19. The *lungs* are light elastic sacs full of air-tubes and blood-vessels and filling the greater part of the chest cavity. The air-tubes open freely through the *trachea* to the air outside the body. The branches of the trachea, called *bronchi*, divide and subdivide, finally ending in minute air-cells near the surface of the lung. Each air-cell is enclosed in a network of capillaries. The lungs occupy an air-tight cavity, and the atmospheric pressure inflates them sufficiently to make them fill all the space and keep it filled, whatever changes take place in the size of the cavity. The chest cavity is enlarged by two muscular movements taking place at the same time:—elevation of the ribs and depression of the diaphragm.

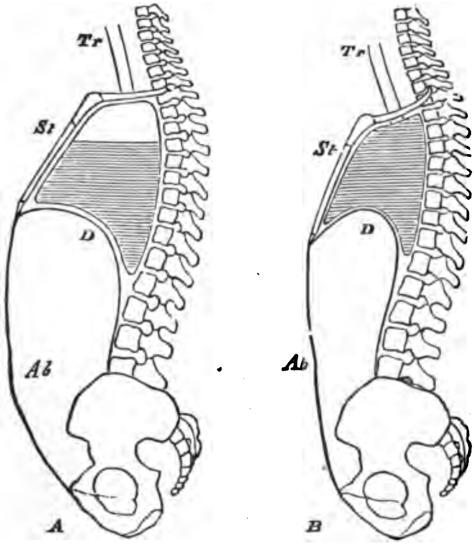

Fig. 18. Diagram to show change of position of the body wall during breathing. A, in respiration. B, in expiration. (From Huxley.)

(1) In quiet breathing the ribs and sternum are raised principally by the contraction of the intercostal muscles. These muscles are placed between the ribs, the fibers extending diagonally from one rib to the next. While extending in a curve sidewise and then forward from their hinged attachments to the backbone, the ribs slant downward at a considerable angle. When they are raised, therefore, the sternum is

carried farther from the spine and the sides of the chest farther from each other, thus enlarging the chest forward and sidewise.

(2) The diaphragm is a flat muscular sheet which forms the base of the chest cavity. It is dome-shaped when relaxed, and is flattened by contraction of its own fibers. This enlarges the chest cavity from below. In doing this the diaphragm pushes the stomach, liver, and intestines downward, causing a slight expansion of the abdomen at the waist-line. Constriction of the waist interferes with this movement and renders movements of the diaphragm difficult or impossible.

In quiet breathing, expiration is accomplished without muscular contraction. The inflation of the lungs stretches their tissues, the elevation of the ribs stretches the connective tissues of the chest wall, and the depression of the abdominal organs stretches the abdominal walls. When the muscles used in inspiration are relaxed, the elasticity of these tissues, with the weight on the chest, brings them back to the starting point.

In forced expulsion of breath, as in speaking, singing, etc., there is contraction of the abdominal muscles, by which the abdominal organs are pressed upon and the diaphragm pushed up. Persons who have lost the use of the abdominal muscles cannot speak above a whisper. Full control of the breath for speaking and singing requires the combined action of the abdominal muscles and the diaphragm. The movements of the ribs are not capable of so complete control.

Normal breathing is automatic and rythmical, like the action of the heart. Unlike the heart, the action stops short when the nerves supplying the breathing muscles are severed. The *respiratory center* not only presides over the

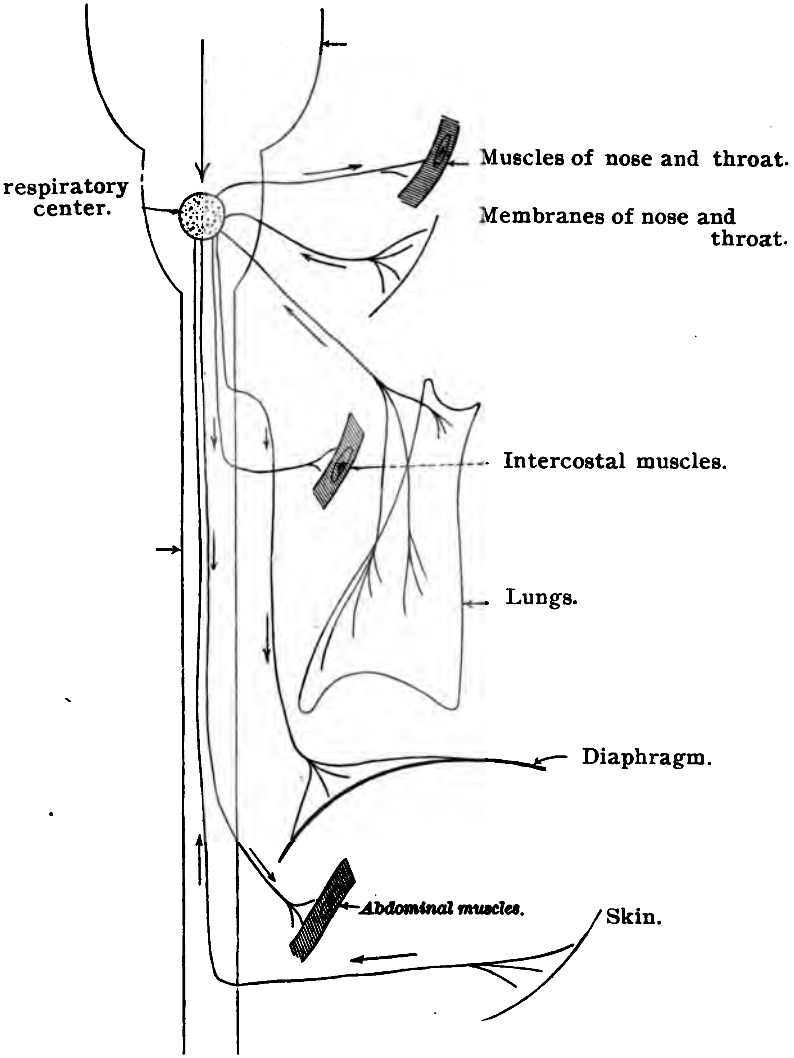

Fig. 19. Nervous mechanism of breathing.

range and rapidity of the movements, but it is necessary to the existence of breathing movements. The automatic part of the mechanism is in this case the center, which is at the same time under the influence of impulses reaching it from the brain and all parts of the body. It responds instantly to an increase of waste products in the tissues, showing noticeable increase with the slightest additional exercise. Particular stimuli cause modified forms of the movement, such as coughing, sneezing, sighing, yawning, laughing, crying, etc. Voluntary control of the breathing is very important, as we are not only able to control the movements to suit our purpose at any given time, but also to modify the habit of breathing, so as to change, somewhat, its manner or form. In other words, the respiratory center is susceptible of education, like other centers of reflex action.

The movement of the wall of the chest or abdomen during breathing may be recorded by the apparatus used in recording heart action, except that in place of a tambour for receiving we use a bulb.

We have seen how the chemical activities in the tissues consume food and oxygen and form certain waste products. We have also noticed some of the injurious effects of these substances upon the tissues, and something of the urgent haste with which the body endeavors to get rid of them. The elimination of these poisonous gases consists of the following four steps:—

(1) The gas, principally carbon dioxide, passes from the tissue where it is formed into the blood in the capillaries. There are three reasons for this movement of the gas. First, it tends to diffuse in all directions, with a force proportionate to the difference of its densities in the different places. Second, it passes readily through the

thin membranes of the animal body, consisting, in the present case, of the sarcolemma of the muscle-fiber and the wall of the capillary. Third, it is readily absorbed by water, which constitutes about 85 per cent. of the blood.

(2) It is transported in the blood from the muscles to the lungs. This, as we have seen, is due to the action of heart, aided by the action of other muscles.

(3) It passes from the blood, now in the capillaries in the lungs, to the air in the adjacent air-cells; a process very similar to the first step, and having the same explanation.

(4) It is removed from the air of the lungs by breathing. In quiet breathing about 25 cu. in. of air is expelled at a breath. This is only about $\frac{1}{10}$ of the air in the lungs, so that the elimination by a single breath is not complete.

A consideration of these processes shows us that two of them depend upon muscular action, with their success dependent upon the strength and healthy activity of those muscles. The other two depend upon natural forces, the completeness of elimination being dependent upon differences in the densities of the gas in the muscle-fibers and in the air outside of the body,—in other words, upon the completeness of ventilation.

It follows from what has been said that the effect of bodily exercise upon respiration consists in a quickening of the processes in each of the four steps; the increase in the rapidity of diffusion of the gas in the first and third steps being due to the increased density of the gas in the muscle-fibers, and the increased muscular action of the second and fourth steps resulting from stimulation of the cardiac and respiratory centers. Since it is by the action of the heart and the breathing muscles that all the carbon dioxide formed in the body has to be eliminated, it is evident that the amount of work thrown upon these muscles at any time will depend upon the *size of the muscular area* that is being exercised and also upon the *intensity of the exercise.* Looking at the same question in another way, we may say that the quantity of waste products to be removed, and consequently, the amount of work to be done by the heart and breathing muscles, is proportional to the *total amount of work done* in the exercise. Now the total amount of work done is the product of the weight lifted by the distance through which it is lifted. For example, a person who weighs 150 pounds, in walking up stairs 10 inches in height at the rate of two steps per second, does work at the rate of 250 foot-pounds per second. This would increase the heart rate and breathing considerably. To do the same amount of work on the ergograph one would have to lift a ten-pound weight to the height of five inches at the rate of 60 times per second,—which is clearly impossible. If the amount of work done in a short time is very great, it produces a condition known as *breathlessness.* This is characterized by very strong and rapid action of heart and breathing muscles, accompanied by an apparent difficulty to empty the lungs. The latter is really a temporary *congestion* of the lungs, or unusual enlargement of the capillaries and arteries, caused by the strong action of the heart and relaxation of the arterial walls by vaso-motor influence.

20. Of the energy liberated by the chemical activity in the muscles, only about 15 per cent. is in the form of mechanical motion. Nearly all the remainder of it is in

---

REFERENCES.—Foster, Howell, Rettger, Waller, Landois and Stirling.

the form of heat. The heat thus produced keeps the body warm, and the excess is lost. A small amount is thrown off with the excretions and the air expired, but nearly four-fifths of it is lost through the skin. With the great variation in the amount of exercise taken at different times and the wide ranges of temperature of the air outside the body, we would expect great changes in the bodily temperature. In spite of all these varying conditions, bodily temperature is almost constant in health, at 95.5° Fahrenheit.

The maintenance of uniform bodily temperature is so essential to comfort and health that much is done voluntarily to secure it; shelter, fire, clothing, baths, changes of food and drink, and exercise being among the means so used. The more exact and minute regulation of the temperature of the body is nevertheless accomplished by reflex mechanism within the body itself. First may be mentioned the agency of the blood in distributing the heat to all parts of the body. In vigorous exercise not only the working parts are warmed, but the blood scatters the heat throughout the system. It has been found by experiment that when one is in a colder place more combustion takes place in the tissues than when in a warmer place. The test is made by measuring either the oxygen consumed or the carbon dioxide exhaled. The fact is explained upon the theory that sensory impulses produced by heat and cold act upon the motor cells of the spinal cord and thus influence the activity of the protoplasm in the muscles, where most of the heat is produced. When impulses caused by heat enter the cord, the heat producing activity is inhibited; when the stimulus is cold, the activity is increased. The existence of a center for the control of heat production is accepted by some authors and denied by others.

The rapidity with which heat is lost from the surface of the body is controlled by two reflex mechanisms. (1) Impulses which enter the spinal cord as the result of external cold act upon the vaso-motor center, and as a result, arteries supplying the skin are constricted and those lying deep within are dilated. When the sensory endings that respond to heat are irritated, the action is the reverse, sending more blood to the skin. (2) The presence of more blood in the skin increases the activity of the sweat glands, causing them to pour out upon the surface an increased amount of moisture. The sweat glands are at the same time under direct control of a center called the *sweat center*, which is situated near the other centers mentioned. The evaporation of moisture is a very efficient cooling process.

21. Brisk exercise causes the liberation of so much heat that nature uses all means to throw it off. Consequently, when such exercise is concluded, the skin is wet and the clothing often saturated with perspiration. With the conclusion of the exercise the production of heat almost ceases, necessitating a checking of the loss of heat. The vaso motor mechanism soon decreases the amount of blood sent to the skin, but unless the evaporation can be stopped, the temperature is apt to fall below the normal point and the person will "take cold." It is necessary at such times to remove the moisture from the skin and to put on dry clothing. We have here one of the chief reasons why physical training is usually taken in special clothing, and why facilities for bathing are commonly provided with it.

For the reason just given, all exercise vigorous enough to leave the skin wet with perspiration should be followed by a bath and change of clothing. Water has so great a capacity for heat that it has an intense influence upon the heat regulating mechanism. The condition in which it leaves this mechanism depends entirely upon the temperature of the water.

When one bathes in warm water, especially if the body is immersed in warm water, the regulating mechanism has to do its best to get rid of the heat fast enough. It checks the production of heat in the tissues, sends as much blood as possible to the skin, and stimulates the sweat glands.

In a cold bath the body loses heat with the greatest rapidity. The regulating mechanism meets this emergency by stimulating the production of heat, constricting the arteries supplying the skin, and checking the flow of perspiration.

As a preparation for meeting outward changes of temperature without taking cold the latter is plainly preferable. The warm bath leaves the system in about the same condition as the exercise, with the muscles more relaxed and the heat production at the lowest point. The only time at all suitable for such a bath is just before retiring, or at some time when the body can be protected from cold air and draughts for two or three hours. The cold bath, by causing a stimulation of the whole system, an abundant heat production, and keeping the blood within, puts the body in the best possible condition for withstanding changes of temperature.

Whatever the temperature of the bath, it should be followed by thorough drying of the skin, or it will cause the same bad effects as when perspiration is left on the surface. It should also be borne in mind that a cold bath takes heat from the body so rapidly that it is weakening unless it is brief. The warm bath, taken for cleansing, requires time, and may be prolonged without harm.

The exact temperature of water that is suitable for a cold bath depends entirely upon the individual. It should be cool enough to have the right kind of influence on the heat regulating mechanism, but not cool enough to chill the body nor cause too intense a stimulation. The latter tends to cause nervousness and sleeplessness. Those who are fleshy and phlegmatic are benefitted by baths that are too cold for the thin and nervous. A sponge bath is milder than a plunge or shower of the same temperature. Probably the best plan for all to follow until they learn exactly what kind of bath is best for them, is to begin with warm water and cool it gradually until it begins to feel cold, then stop and dry at once by brisk rubbing. Persons having heart trouble should get advice from a competent physician about bathing, and follow his directions closely.

22. Ever since ancient times it has been known that tissues develop with use; that a muscle that is used becomes larger, stronger, and in all ways more healthful than one that is not. No fact of science is more firmly established. This development with exercise is remarkable for the seeming intelligence which fits the organ for the work that is required or it. If the exercise demands strength, then strength is developed; if endurance, endurance; if swiftness, swiftness; if agility, agility. The fatigue, which results immediately from exercise, has been found to be located partly in the nervous system. The development, which results more slowly, can likewise, with good reason,

---

REFERENCES.—Animal heat, bodily temperature, heat regulation,—Foster, Howell, Waller, Landois and Stirling. Baths,—Stephenson and Murphy.

be said to take place, in part, in the nervous system. Especially those finer shades of difference in the changes produced by different exercises may be considered without doubt as taking place in the nervous system rather than in the muscle substance.

We are by no means so sure about the explanation of these effects. The development may be brought about (1) through the agency of special nerve-fibers, which are thought by some to preside over the nutrition of the tissues. Such a hypothesis might account for all the changes that take place, but it can scarcely be said that the theory has been proven. It may be (2) that the protoplasm of the muscular and nervous systems possesses a sort of intelligence, which guides it in taking from the blood what it most needs, and in building up its worn out portions in preparation for future emergencies. Although sometimes seeming probable, this has not been proven. It may be (3) that the whole effect is produced by the greater blood supply that is sent to the parts that work, through the agency of the vaso-motor center, together with the action of the heart. It has been proven that mere increase of blood supply will cause increase of the size of the part. If certain nerve-fibers of the face are cut, there results a dilation of the arteries of the ear. In the case of rabbits in which this has been done, the ear so affected is found to become gradually larger, sometimes attaining a size three or four times that of the other.

23. The development that follows exercise, and the repair of the tissues necessitated by the increased combustion, must be accomplished by the use of food materials taken from the blood. When exercise involves vigorous work for a large muscular area, and is continued for some

time, the amount of food materials thus taken from the blood is considerable. This, in turn, increases the rapidity with which the blood absorbs food materials from the digestive system. The blood is capable of absorbing a certain amount of soluble food. The more it gives up to the tissues, the more it can take in of the digested food. The amount of exercise in this way influences the activity of the digestive organs. The presence of food in the stomach stimulates the glands and the muscular movements of its walls, but in order to insure healthful activity the food digested must be absorbed. If it remains in the alimentary canal it decomposes and becomes poisonous. Then come loss of appetite, headache, billiousness, and sometimes dyspepsia. A reasonable amount of vigorous general exercise is as necessary to the health of the digestive organs, especially in younger persons, as it is to the welfare of the heart and lungs.

Digestion is a complex process, involving the activity of many large glands and the movement of a large amount of involuntary muscle. It necessitates the presence of a large quantity of blood, which is sent to it by action of the heart and the vaso-motor mechanism. If voluntary exercise of the muscles or brain calls at the same time for a large increase of blood supply, the digestion is necessarily interfered with. Vigorous exercise, either physical or is mental, therefore detrimental during the digestion of a hearty meal. Gymnastic exercises should for this reason be placed as far from meal time as circumstances allow,—never nearer than half an hour before or an hour after a meal.

CHAPTER III.

POSTURE, AGE, SEX, ETC., AS RELATED TO HEALTH AND BODILY EXERCISE.

24.—The choice of material and method in Physical Training depends not only upon the general physiological facts to which reference has been made, but also upon certain conditions affecting health, bodily vigor, and the needs of the organism. Certain faulty postures, frequently resulting from school life and habits, need correction. Exercises suited to pupils of one age are not at all suited to older or younger pupils. Exercises best adapted for high school boys are not the best that could be chosen for high school girls. Soldiers, students, stenographers, athletes, and invalids each need a special kind of exercise, and school children need still another. Bodily conditions of frequent occurrence call for the avoidance of all physical exercise, as far as possible. The nature of these conditions will be considered here.

25.—A definition of normal posture involves two views of the body,—one from the front or back and one from the side. Viewed from front or back, there is bilateral symmetry. This means that a vertical plane passing in an antero-posterior direction through a point midway between the feet will divide the body into two equal parts. The weight is divided equally between the feet, the spinal column is straight and vertical, while the hips, waist, chest and shoulders are of the same height on each side and equally distant from the spine. When a view from the side is taken, we see that the weight is poised well forward over the balls of the feet, knees and hips straight (not overextended); and the trunk exhibiting the three normal curves in the *lumbur*, *thoracic*, and *cervical* regions.

The framework of the body consists of a great many separate bones, so joined as to admit of free movement, and poised upon a small base below. In the trunk we have an exceedingly flexible column of twenty-four vertebrae and twenty-four intervetebral discs. This rests upon the pelvis, which, in turn, is poised upon the bones of the lower limbs. The weight of the parts above tends constantly to deepen the normal curves and to flex the joints of the supporting limbs. The base of support is so small that a slight deviation of any part from its position necessitates a compensating deviation of another part in the opposite direction. It is evident, therefore, that normal posture must be maintained in constant opposition to the force of gravitation, and at the expense of a considerable amount of energy.

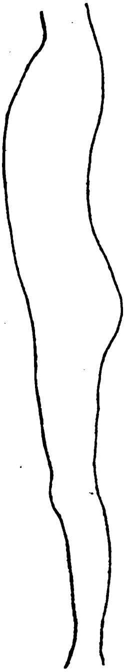

Fig. 20. Normal posture.

The first essential of normal posture is strong, healthy, and correctly shaped bones. A broken leg or a diseased or distorted vertebra at once renders normal posture impossible. A complete set of ligaments, binding this system of bony levers into a movable but inseparable framework, is another essential. A broken ligament is as serious a difficulty as a broken bone. Yet bones and ligaments are after all only helpless, passive instruments to be used by the muscles. The elasticity of the muscles avails something in holding the body erect, but it is their contractile power, under control of the nervous system, upon which most depends; otherwise a man shot in battle, or one fainting or falling asleep while standing, would not change his position.

Every young child learns how to stand and sit as voluntary movements, but in the usual way they gradually become reflex, and pass under control of the lower nerve centers. Until he learns to stand erect the thighs are flexed upon the pelvis, and the plane of the latter is nearly at right angles to the line of the trunk. The spine presents one continuous curve, convex backward, from the head to the pelvis. When he straightens up, the muscles and ligaments in front of the hip joint prevent the pelvis from taking the horizontal position, and keep it tilted forward at a considerable angle. The upper surface of the sacrum, upon which the spinal column rests, tilts forward at about the same angle. This necessitates a backward bending of the trunk, giving rise to the lower or lumbar curve of the spine, with the convexity forward. The original curve remains in the middle or thoracic region, while the raising of the face to look forward produces the curve in the cervical region.

26.—While deviation of any part of the body from its normal position is more or less inconvenient and unsightly, the maintenance of normal posture is most essential in case of the trunk, because it contains the vital organs and the spinal cord and spinal nerves, any of which may be crowded or displaced. The position of the lower limbs is incidentally important, because they support the trunk and its posture depends largely upon theirs. In a similar, though less important way, the position of the arms and shoulders influence the posture of the trunk.

It should be borne in mind throughout the discussion that the prime factor in faulty posture, ever present and unavoidable, is the force of gravitation. It is true that the child, in learning to stand and walk, solves the balance problem which gravitation necessitates, and usually acquires a correct posture. But when, later in life, the bad postures appear, it can be seen that the deepening of the curves, the existence of compensating curves, the distortion of the tissues and the bones, the pressure upon the vital organs, and the tendency to grow from bad to worse, all result from the constant downward pressure which gravitation exerts upon everything.

Among the circumstances and conditions from which abnormal postures arise, lack of sufficient muscular strength and endurance plays a very prominent part. No one has enough endurance to stand erect for an indefinite time. It is a mere matter of time when the strongest man will fall from complete fatigue. We avoid such extreme fatigue by spending about one-third of our time in bed, where all the muscles can be relaxed, and by varying our attitudes while standing and sitting, so that we can rest a part of the muscles while using others. Such occupations as writing, drawing, sewing, using the microscope, etc., are apt to cause bad postures, partly because the positions assumed in the work are apt to be bad, but principally because a fixed and fatiguing position is necessary. As soon as the muscles are fatigued to a certain degree, the pupil relaxes into whatever position is most restful.

The investigations of many experts, who have tried to learn the causes of bad posture among school children by observation of the children at work, point to the conclusion that postures of the kind just considered can be largely prevented by providing more comfortable seats, sufficient exercise of the right kind, and by permitting frequent change of attitude. No amount or kind of exercise will prevent the appearance of bad postures if the children are compelled, for any reason, to hold fixed positions for a considerable length of time. The seats and desks are often ill-shaped and uncomfortable, or of a wrong size, which brings on the fatigue more quickly. The growing interest of the people in the physical welfare of their children as well as in their advancement in learning is leading slowly toward the providing of better school furniture. Seats and desks are now being manufactured with a view to comfort, and some are made adjustable, so that the height of desk and seat can be fitted to the child. Separate places are provided for writing, where a level surface is needed, and for holding the book for reading, where a slanting top is better. Without going into details, the modern seat and desk are decidedly better and less conductive to fatigue than the old forms.

Many causes of bad postures of school children lie outside of the school. Poorly fitted clothing, habitual methods of carrying school books, habitual positions in sleeping, are examples of an almost endless list of causes.

The tendency of muscular fatigue to produce faulty postures is greatly increased by muscular weakness, resulting from insufficient food, clothing, or exercise, or from illness or any other cause. The same can be said of certain mental states, such as discouragement, melancholy, sullenness, etc. The weak minded and criminal classes are especially subject to bad postures. Muscular weakness is sometimes brought about by a wrong use of artificial means of support, such as braces, corsets, casts, etc. Those devices, often useful, temporarily, following illness or injury, are of great detriment when used continuously for a long time, because they take from the muscles the exercise which is their natural means of development. The result is a wasting away of the muscles and consequent perpetuation of the weakness.

In the history of cases of abnormal postures resulting from occupation or fatigue there may be three stages. In the first stage, which may be called the *accidental* stage, the posture is assumed because circumstances favor it. The pupil droops forward while he writes, the clerk droops sidewise while he stands on one foot and leans on the counter, but each leaves the position as he leaves the place and the occupation. He can stand straight, and naturally does so. In the second or *habitual* stage a certain position that has been frequently assumed in this way becomes habitual. The crooked posture goes with him, and he feels unnatural if placed in a straight position. The nervous system has been so accustomed to co-ordinating the muscular contractions abnormally that it seems natural to him. He has the strength to straighten up, but he has forgotten how it is done. The effect of the posture upon the vital organs is now worse than in the former stage, because he holds it all the time. In the third or *permanent* stage the bones and connective tissues have adjusted themselves to the abnormal position, and he lacks the strength to correct the attitude, even if he knew how.

In the first stage the remedy is prevention. It is only necessary to see that no abnormal attitude becomes habitual. In the second stage one has to learn over again the correct posture that he once learned as a child, and must practice it until it becomes habit again. In the third stage the work of the second must be be complemented by a long course of treatment, including mechanical force to aid in the straightening. Even then recovery is doubtful.

27. Besides the abnormal postures arising from fatigue, habit, and occupation, there are numerous cases produced by an entirely different group of causes. First among them may be mentioned diseases of the bones. Some of these, like hip joint disease and white swelling of the knee, attack the joints, usually leaving the movement impaired and frequently destroying all movement in the joint. Others are characterized by imperfect nutrition of the bones, so that they are weak, sometimes distorted, and unable to bear the weight. Still another, Pott's disease of the spine, destroys portions of one or more vertebrae, usually resulting in a marked deformity, which may be such as to interfere with the functions of the spinal cord and interrupt the nutrition and growth of the tissues. Similar deformities may result from injury of the bones or joints from accident. In some cases the main difficulty is lack of development of certain parts of the body resulting from temporary paralysis of those parts following a disease in infancy. The child recovers from a severe illness with one side of the body or a part of it much weakened, and the ability to control those muscles impaired. The paralysis gradually passes away, but in the mean time the child has learned to use the strong side skillfully and has developed the strength of that side rapidly. Although the weak part is capable of development through exercise, he dislikes to use it, as it is neither so strong nor so "handy" as the other. Often the weak arm will not be used for fear of appearing awkward. For such reasons the weakness, with its accompanying deformity, persists for years and often for life. The same con-

ditions may result from any cause that prevents the use of certain parts of the body for a considerable period, especially if this is during the age when habits of movement are most rapidly formed. Occupations requiring constant and vigorous use of some muscular groups while othere are left unused lead to lack of symmetry and abnormal posture of about the same character.

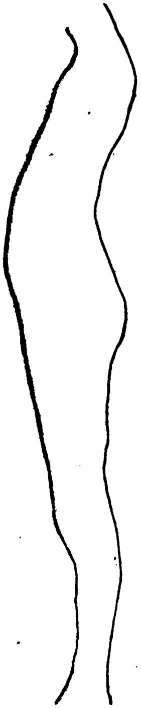

Fig. 21. Kyphosis.

28. Three particular forms of abnormal posture are so common and so important as to merit special consideration. (1). The most common of these is *kyphosis*, commonly known as "round shoulders." It is an exaggeration of the natural thoracic curve, usually resulting from the relaxation of the deeper muscles of the back in the upper thoracic region. The head and neck are too far forward and the shoulders are sometimes drawn forward also, rounding the back. There are several objections to this position, but the principal one is because of its effect upon the chest. The muscles passing from the head and neck to the ribs and normally helping to hold the latter up in their proper position are relaxed from above, allowing the ribs to sink. The abnormal deepening of the thoracic curve acts also to depress the upper ribs, because of their firm attachment to the vertebrae, which are tipped forward. Thus the upper part of the chest is flattened in front, and the breathing is shallow. The heart, stomach, and other organs are crowded and their action hindered. The general vitality is lessoned and there is increased tendency to lung diseases.

(2). *Lordosis* is an exaggeration of the lumbar curve of the spine. It often resultss from relaxation of the abnominal muscles, allowing the hips to sway too far forward and the shoulders to go too far backward. In some cases the pelvis tips forward at too great an angle. The abrupt curvature causes the weight of parts to be transmitted through the posterior part of the bodies of the vertebrae, and so lessens the supporting power of the spine where its strength should be greatest. Lordosis is often accompanied by weakness and pain in the small of the back, which is usually attributed to lack of strength of the back muscles. On the contrary, the pain is due to the concentration of the pressure at the edges of the vertebrae, and the deficiency is in the abdominal muscles. The training of the muscles to hold the pelvis and the spine in normal position will usually bring relief.

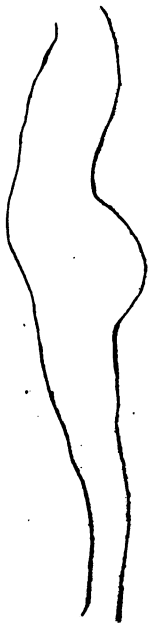
Fig. 22. Lordosis.

(3). A deviation of the spine to the right or left of the vertical is called *lateral curvature* or *scoliosis*. Causes of scoliosis may for the sake of clearness be put in two groups: those acting directly upon the spine, and those acting upon the base upon which the spine rests,—the pelvis. The causes of the first group include an innumerable lot of circumstances too trival to be noticed at at first, but which, through repetition and habit, induce the curvature. Among such causes may be mentioned carrying a load frequently in the same hand or on the same shoulder, carrying a package or bundle always under the same arm, carrying the head habitually on the same side, sitting with the same side against the table whenever one writes or draws, lying always on the same side in bed, etc., etc., Lateral curvature necessarily follows whenever one side of the pelvis is higher than the other, with the convex side of the curve toward the lower side of the pelvis. This is because the spine normally leaves the pelvis at right angles to the line between the hip joints. The pelvis may be thrown out of the horizontal by inequality in the length of the lower limbs or by the habit of standing much of the time on the same foot. One-sided development of the lower limbs arising from infantile paralysis may induce either of these conditions.

The form of a lateral curve usually changes and becomes more complex in later stages. Consider as an illustration the case of one who stands habitually on the left foot. The unsupported side of the pelvis sinks, partly from the weight resting on it normally and partly from the weight of the relaxed limb, which now drags down upon it from below. The spine, as it leaves the pelvis, inclines to the right, and then, in order to preserve the balance, sweeps gradually over to the left. The shoulders tip in an opposite direction from the pelvis, and the head is held to the left. The spine thus takes the form approaching the letter C, and the curve is called a "C curve." The deviation from the perpendicular is considerable, causing a considerable strain upon the side muscles of the convex side. As a result of the fatigue and discomfort thus occasioned there is a tendency to bend more sharply to the left in the lumbar region, and then to preserve the balance by bending

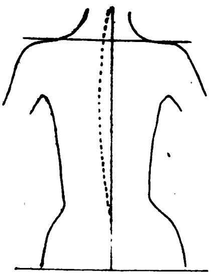

Fig. 23. Scoliosis. The "C" curve.

sharply to the right in the thoracic region, tipping the shoulders in the same direction as the pelvis and holding the head to the right. This gives what is called an "S curve," the lower curve being known as the primary curve and the other as the compensating or secondary curve. In the S curve the amount of deviation from the vertical is less in any one place than in the C curve from which it develops, but the curves are sharper, with increased deformity of the vertebrae and increased chance of compressing the spinal nerves as they pass out of the spinal canal. The weight constantly tends to deepen all the curves, especially if the muscles are weak or fixed positions required. It should also be said that upper curve may be the primary curve and the lower one compensatory, as in a case produced by the habit of carrying the head on one side.

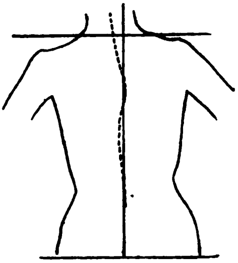

Fig. 24. Scoliosis. The "S" curve.

Besides the decrease of supporting power and displacement of the vital organs that always accompany scoliosis there is another inseparable condition fully as serious in its consequences. The anterior portion of the spinal column consists of the bodies of the vertebrae and the intervertebral discs. They are intended to support the weight, and consequently resist compression. The greater the deviation from the vertical, the greater is the tendency for the weight above to push this part of the spine still farther. The posterior portion of the column consists of neural arches and spinous processes. They do not rest upon one another, but are connected by strong ligaments and muscles which resist any separation of the processes and tend to draw them closer together. The greater the deviation from a straight line, the greater is the tendency of this portion to resist such deviation. It necessarily follows that whenever the spine is bent to one side the bodies of the vertebrae will tend to go to the longer or convex side of the curve, while the processes will tend to go to the shorter or concave side; in other words, the anterior portion of the spine will move farther from the vertical than the posterior portion. But the posterior portion is the portion that is visible, and the portion from which we must estimate the amount of curvature. The actual amount of curvature will therefore always be greater than the apparent curvature, as indicated by the line of spinous processes. Again, the greater deviation of the anterior portions of the vertebrae is equivalent to a rotation of each vertebra thus moved, about a vertical axis. According to some authorities, the rotation sometimes precedes and leads to the bending. In either case the rotation, if it is in the thoracic region, produces a pronounced distortion of the chest by the effect of the torsion upon the ribs.

29. In attempting to correct faulty postures, as in any similar proceeding, common sense would suggest the removal of the cause, if possible. In the early stages of the curvature that is often all that is necessary. Giving the child a suitable seat and desk, avoiding the requirement of fixed positions of long duration, breaking up (with his coöperation), his habit of standing on one foot or carrying his books always under the same arm, lengthening the short limb by means of a thicker sole for the shoe, etc., are necessary and often sufficient steps toward recovery. In some cases the correction may be hastened by replacing the cause by a like cause of opposite phase, as when the habit of

standing on one foot is replaced by persistently standing on the other foot, or when round shoulders is treated by bending the head and neck backward. In the same class are the correcting of uneven hips by sitting upon a seat sloping in the opposite way, or when, in suspending the body by the arms or neck, gravitation is made to help straighten, rather than to curve the spine. It is well, however, to warn teachers against careless or hasty conclusions as to the cause of this or that posture. The causes are so numerous and the cases resulting from them so similar that unless you have had long experience in studying such cases it is best to watch a child long and carefully before coming to a conclusion.

General exercises for developing strength and endurance of the trunk muscles are always useful. Care should of course be taken, in whole classes of children as well as in cases of curvature, that the exercise is well balanced, giving equal work for both sides. Poising and balancing exercises, bendings and twistings of the trunk, and marches, etc., involving the same movements, are especially of use. With two or three exceptions that will be explained later, the giving of special, local exercises for the correction of curvature may best be left to specialists. The difficulty of determining the exact cause and anatomical condition of the curvature, and the likelihood, in case of a mistake, of causing another deformity instead of curing the existing one, makes it advisable for the teacher to depend upon general exercises alone. Much good may be done by calling the attention of parents to severe cases, and informing them of physicians who are experts in this line.

The most efficient service of all that that the teacher can give in this direction is through the use of what is known as the *key-note position* or the *fundamental standing position*. The technical details of this position will be given in another place. It is sufficient here to say that by use of it the teacher gives a vivid conception to the pupils of what a normal position really is, teaches them individually to correct their special faults and so to assume this position, and leads them to practice it regularly and frequently enough to make it habitual.

30. The body of a child, during the early years of school life, is unlike the body of adult in size, form, structure, chemical composition, and normal activity. The boy of five has one-third of a man's weight with two-thirds of a man's height; his cranium is large in proportion to his face, his head in proportion to his trunk, and his trunk in proportion to his limbs. His bones are soft and pliable. His joints are exceedingly supple. His muscles have proportionately much protoplasm and little connective tissue, and the nuclei are very large. His tissues contain 50% more water than those of an adult. The chemical changes in the tissues are much more rapid, in consequence of which the normal temperature is higher and respiration faster. The heart is small and the arteries large, and as a result the blood pressure is low and the work of the heart light and rapid. His digestive fluids are different in composition and action, calling for a somewhat different diet. In general, the child is in a temporary, changing period of evolution, with "unripe" tissues and undeveloped mind.

In the nervous system there is further evidence of the unfinished condition. In the nerves are some fibres not yet medullated; in the spinal cord, many cells are just developing their fibres; in the brain the areas of the cortex concerned in the larger, coarser movements of the body are partially developed, while those that preside over the more minute movements of the hand, eye, etc., are in earlier stages of evolution. It is worth knowing that there is a definite order in the development of the motor ability; the muscular groups moving the head and limbs upon the trunk being controlled first, those moving the elbow and knee next, and the finer movements of wrist, ankle, hand and foot last. Use and development go naturally together, but the attempt to develop a part or a function prematurely by exercise is to be deplored. The development of muscular strength, or skill, or any other "manly" ability before its time is abnormal and undesirable.

At the age of five the average American boy is growing at the rate of a little less than four pounds a year, and he gains in the same time something over two inches in height. The yearly increase in weight and height contidues about the same until the age of eleven or twelve, when there is a period of about a year in which the growth is less. From this time begins a period of more rapid growth, lasting nearly four years and reaching the amount of twelve pounds or more in weight and nearly three inches in height during the sixteenth year. The average American girl shows the same changes in rate of growth, but in the case of girls the period of slow growth is at the age of nine or thereabouts, while the time of most rapid growth is between ten and fifteen. Thus it is seen that girls begin the most rapid rate of growth while the boys are in the period of slow growth; consequently there is a period of from two to four years in which girls are taller and heavier than boys of the same age. Statistics show also that before the boys have passed through their most rapidly growing period the girls have stopped growing, the boys finally becoming both taller and heavier.

The period of most rapid growth is shown by the mortality tables of the Insurance Companies to correspond quite closely to the time of life when there is greatest immunity from sickness, and the time when the death rate is lowest. The period of slow growth just preceding, and the year or two following, are found to be special times of liability to disease, more noticeably nervous disorders and heart troubles. The girls and boys,—who, up to the time of rapid growth, are much alike in physical characteristics, —take on during this time the characteristic forms and aptitudes of men and women. One change that is similar in the two sexes should be noted,—the change in the circulatory system. The heart increases to twelve times its former size, while the caliber of the arteries increases but three times. The resulting increase in blood pressure greatly augments the work of the heart, whose walls must be developed proportionately before the hardest exercise can be taken with safety. This points to the need of a great amount of exercise throughout the period of rapid growth, in order to develop the heart's walls, and the danger of excess in feats of strength and endurance during the same time. The tendency to heart troubles in the year or two following is no doubt related to the changes that have taken place.

When a child fails to keep up with the normal rate of growth, it may be a matter of heredity. The greater chances are, however, that unfavorable surroundings have prevented him from growing naturally. Among such causes may be insufficient food or clothing, poor ventilation, lack of exercise, or the effect of disease. As an indication that such things are causes of slow growth, it has been found that it is the children from homes of comfort and luxury who are largest and strongest, rather than those of the laboring classes; that children grow faster in summer than in winter, etc. It has also been shown that the pupils who are most successful in school are the larger ones. Among 1700 boys of 11 years (in the schools of St. Louis, Mo.), scattered through the first six grades, those of each grade averaged heavier than those in any grade below, and lighter than those in any grade above.

31. The selection of exercises for the different ages and the two sexes should be based partly upon the different bodily conditions known to exist and partly upon the kind of exercise that is natural and instinctive. With the children of the kindergarten and the lowest two or three grades we have the tissues immature, the nervous system rapidly developing, large movements fairly well co-ordinated, finer movements just beginning to be made, and the blood pressure low. The exercise natural at these years is characterized by almost ceaseless activity, using all the large muscle groups, avoiding excessive fatigue by a change of movement as soon as fatigue appears and without great intensity of contraction. Fatigue comes on very quickly, unless rest or change is given. These conditions and tendencies point to the need of a great amount of exercise to stimulate the circulation and the growth of the tissues, with careful avoidance of strain or extreme fatigue, which, in case of the young child, must be repaired at the expense of growth. In the kindergarten, the simple games of motion predominate, with a few exercises in marching, running, skipping, etc., given wholly by imitation. In the first grade, the games are supplemented by a greater pro-

portion and variety of gymastic exercises involving all kinds of large movements. As the power of voluntary attention develops, the use of commands is made more prominent. The finer coördination now required in the regular school work call for more practice in coördination of large movements, as a physical basis for the former. In the second and third grade the same general character of work is indicated, with gradual increase in the accuracy of the movements to keep pace with the development of the motor ability. The frequency of heart difficulties during these two grades suggest even greater care to avoid excess of effort or fatigue.

In the next three grades the pupils have entered upon the period of most rapid growth, and the increase in motor ability calls for exercises of greater skill. The need of a large amount of exercise still continues, and the condition of the tissues makes stronger work admissible. Games become more complex, and complicated and fancy drills with light apparatus are enjoyed. The girls begin to like lighter and more graceful forms of movement, while the boys prefer more vigorous exercises. This is preëminently the time for acquiring alertness or agility, and the habit of graceful carriage and movement. Defects of posture, which are rare below the fourth grade, become gradually more common, and corrective exercises are needed.

In the grades from the seventh to twelfth inclusive the rate of growth is most rapid. The large amount of tissue added to the body needs training, to develop its functions. The time has arrived for the attainment of greater skill, which is best developed by exercises with and upon apparatus. The girls will be best suited with graceful exercises taken in classes, while the boys best enjoy those requiring individual strength and skill. There is, however, much difference in individuals. Faults of posture still call for corrective measures. The tendency to heart troubles at this time indicate the need of caution against excess. The stage of fitness for severe athletic competion has not yet arrived, although all gymnastic and athletic work except the most severe is entirely suitable.

The period beginning at nineteen or twenty is the time for college athletics,—the time of life when there is greatest possibility in the development of strength and skill. Excess is still possible, especially if the body is not well cared for, but injury is less likely to occur than at any former time, as the tissues are well matured throughout.

32. While exercise is frequently useful in certain forms of disease, as well as in health, certain conditions demand complete rest instead of exercise. Among these the most common are fever, inflammation, and hemorrhage. Fever, being characterized by heightened temperature, rapid pulse, etc., resulting from abnormally increased heat production, is necessarily aggravated by exercise, which naturally tends to increase the same activities. Acute inflammatory conditions, such as inflammatory rheumatism, erysipelas, ivy poison, or boils, ulcers, etc., are generally made worse by increase of exercise, because of the quickened circulation. For the same reason exercise tends to increase the loss of blood in cases of hemorrhage. While there are exceptions to this rule, unless the teacher is otherwise directed by a competent physician, it is safest to pupils so affected to avoid all exercise as far as possible.

The prevalence of such diseased conditions among the pupils of the schools, and the fact that, in thèir beginnings they are not easily recognized by parents or teachers, makes the regular inspection of schools by competent physicians very desirable. Many epidemics of infectious diseases could and would be prevented entirely by such medical inspection. At a comparatively slight cost the schools of almost any city can secure one hour per day of a physician's time, which would not only do away with the danger of epidemics spreading in the schools, but also give the school authorities and teachers the benefit of expert opinion upon sanitary conditions.

PART SECOND.

Physical Training.

CHAPTER I.

THE PLACE OF PHYSICAL TRAINING IN EDUCATION, AND ITS CHIEF SUBDIVISIONS.

33. Education is commonly classified as *physical, mental* and *moral.* Physical education includes those activities and processes that help to develop and train the neuro-muscular system. The senses, through which we receive ideas, and the mechanisms through which we give them outward expression, are all physical. Their training therefore belongs to physical education. Learning to talk, to read, to write, to draw, laboratory work, games and gymnastics are familiar examples of the means employed. The mistaken idea so common in the beliefs of the early Christians, and borrowed by them from the still older heathen philosophy, that the body is something noxious and degrading, to be denied its natural development that mind and soul may develop the better, is the fundamental error of the older types of education. Since the rise of popular education there have been great advances toward an appreciation of the necessary physical basis of all education, but the popular mind is too conservative to approve the kind of education that modern science and experience point out as best for the child. The increase of knowledge and sentiment in this direction, however, was never so rapid as now, making the outlook for a rational type of education very hopeful. In the vacation schools in some of the large cities, where the

teachers are held back less by tradition than during the year's work, physical education is already receiving its full share of attention.

34. The two main divisions of physical education are *physical training* and *manual training.* Physical training is that part of education that aims to develop and train the body as a whole, emphasizing the hygienic and general educational effects of bodily exercise. In order to do this it employs the larger movements belonging to the *fundamental* portions of the neuro-muscular system. The term "fundamental" is used in this connection in its usual sense, to designate those primary and essential portions of the muscular and nervous systems which develop first, which are common to all the higher animals, and upon which the vital functions of the body depend. Manual training seeks to develop and train those finer mechanisms of nerve and muscle which are distinctively human attributes, such as the mechanisms employed in speech, song, and various uses of the hand. These mechanisms are known as the *accessory* portions of the neuro muscular system, since they are developed later than the fundamental portions and depend upon them as upon a foundation. Both physical and manual training give constant and direct exercise of the will, practice in concentration of attention, and practice in solving difficult problems of co-ordination, all of which involve activity of the mind, and they afford training of the moral faculties as well. Manual training, since it involves more delicate movements, and since it correlates more closely with scientific and mathematical studies, probably gives the greater amount of mental training. Indeed, some teachers of manual training claim that the mental training afforded is all they seek; that they care nothing for the increased

motor ability. Physical training, especially those portions of it that involve co-operation and other social relations, gives better opportunity for moral training.

35. Physical training includes (1) *play*, and the exercises naturally related to it,—those known under the names of games, sports, athletics, recreation, etc,, and (2) the more formal exercises called *gymnastics*. The most fundamental and natural form of physical training is play. We see this in its simplest and most typical form in the activities of young children and the young of some animals. It is *aimless activity*, instinctive and natural, and hence pleasurable. As the child learns to make voluntary movements, there is added to the pleasure of mere activity the satisfaction of doing something he has seen others do,—the beginning of the *imitative plays* of childhood. By the time he enters school the spirit of emulation shows itself, and plays having a *competitive element* have an added interest. As his judgment and motor ability develop he comes to prefer plays in which he has to accomplish some object by methods of his own choosing, or in accord with circumstances. Here we have the beginning of *games*, into which there is later introduced the element of team-play or co-operation. Finally, as maturity is reached, and the competitive element is made to assume great proportions by the giving of costly prizes, the honor and notoriety attending the making and breaking of records, and the tremendous excitement prevailing at the contests, that which started as the simplest play reaches its climax in college *athletics*. These various stages in the evolution of play merge gradually into one another, so that it is often difficult to define a certain form or to set it off by definite lines. There are also a number of other offshoots from the line of evolution above

indicated, among which, as types, may be mentioned dancing, boating, camping, sea-bathing, mountain-climbing, bicycling, hunting, etc.

Gymnastic exercises differ from play in the artificial and measured character of the movements. In a game each movement is made on the spur of the moment, being suggested by the immediate necessity of the game or the choice of the player; in gymnastics each movement is made according to a preconceived plan which has been made known in the form of a definition or model. Every gymnastic movement is definite as to its beginning. its course, its speed, and its ending. Exercises of this sort are therefore much more immediately and completely under control of the teacher than those of the other group. The relation of the two groups of exercises, plays and gymnastics, is fundamental and important, and it can easily be shown that each is calculated to accomplish some purposes better than the other. In gymnastics the movements can be chosen definitely to suit the needs of the class. Excess can be prevented, faulty postures corrected, symmetrical development provided for, and a wide range of skill and coördination secured. All these things are accomplished, however, at the sacrifice of the spontaneity and self-direction that characterize play, and which develop self-reliance and a habit of enthusiastic and vigorous activity. In the one, the pupil's will submits completely to the will of another and is trained in habits of order, obedience, promptness, and accuracy. In the other the pupil is placed in a community of individuals possessing equal rights and privileges, where the law and its enforcement are in the interests of all, and there he learns the lessons of civilized society: coöperation, honesty, forbearance, courtesy. That is indeed a defective plan of physical training that fails to employ both kinds of work.

36. When gymnastics are used for the treatment of disease they are called *medical* gymnastics. As such they are classified into *active* movements, *passive* movements, and *massage.* Active movements are those made voluntarily by the patient, under direction of the physician. Passive movements are those movements of the body which are like active movements, except that they are made by some outside force, which may be another person or a machine. Massage consists in the manipulation or percussion of the tissues by the hands.

Gymnastics used for educational, developmental, or hygienic purposes are known as *educational* or *pedagogical* gymnastics. In this large division are included (1) *free movements*, taken without apparatus; (2) *light gymnastics*, in which such light apparatus as bells, clubs, rings, wands, hoops, etc., are held in the hands, and (3) *heavy gymnastics*, in which the work is done upon stationary apparatus and the performer lifts his own weight in the exercises.

This division is superficial and inexact, but more or less useful. Free exercises are useful in schoolrooms and other places where no apparatus work is possible, and where no apparatus is provided. Light gymnastics afford an almost endless variety of movements, thus adding to the educational value of the exercise. The third group is in general more advanced and difficult, and consequently more interesting and valuable for those who are fitted for it. The terms "light" and "heavy" as applied to gymnastic exercises in the usual senses of the words, can of course mean nothing except as relative to the condition of health and strength of the individual. Sitting in a chair may be more violent exercises for one than ring or bar work for another.

37. There are four leading lines or systems of gymnastics in use in this country, viz.: the *Swedish*, the *German*, the *American*, and the *Delsarte*. Besides these there are several lines of work such as that of the Y. M. C. A. gymnasia, which are made up of portions taken from the different systems and modified to suit particular conditions. There are also a great number of so-called "systems" which are merely the routine of work used by some individual teacher who has seen fit to publish it and call it his "system of physical training."

The Swedish system is almost without exception the creation of Ling, the founder of the system, and his followers. The work is very systematic, and is characterized by much care and conservatism in the choice of exercises, careful progression, attention to posture and effects upon the vital organs, and especially by a fixed form of routine for the daily lesson. Exercises of this system form an integral part of the school course in all the schools of Sweden and Norway, the special teachers being supplied from the Royal Gymnastic Institute at Stockholm, which is supported by the government. Swedish gymnastics are used extensively in Normal schools and in some city schools in this country.

The German system, far from being the work of any one man, consists of a vast store of material drawn from many distant sources. At its beginning, Gutsmuths and Vieth collected all that could be found of the exercises of the ancient Greeks and Romans. Later, Jahn, the founder of the organization known as the Turners, borrowed and invented many forms of the stationary apparatus and exercises suitable for it. Speiss collected, arranged and invented the free and light gymnastic exercises. Strength from variety and freedom of exercise is the cardinal principle. The Turner societies, numbering many thousands of active gymnasts in this country and Germany, with their enthusiastic and capable teachers and their public exhibitions of attractive drills and skillful apparatus work, have probably done more than any other one thing to give physical training the prominence it now holds with the general public.

The American system is the name often applied unofficially to the line of work done in the American colleges. It is characterized by physical examinations, special attention to the needs of the individual, and the use of pulley machines for prescribed exercises. The leaders in this work have been a group of able physicians, prominent among whom are Drs. Hitchcock of Amherst, Sargent of Harvard, and Seaver of Yale. Their work in bodily measurements has received world-wide attention, has influenced physical training in all systems and places, and no doubt had a considerable influence in stimulating the present movement for the scientific study of children.

The Delsarte system is a system of training designed by its author as special preparation for professional work upon the stage. As a system of training for actors, impersonators, etc., it is without a rival. While it includes some types of movement that are of great value in physical training, the system, as a system, is too advanced, difficult, and technical for general use. Attempts to make a system suited to all ages and classes of people by selections from Delsarte have not met with favor by those best acquainted with the purposes and the systems of physical training. The attempts of this sort made in this country have also been discredited by the lack of knowledge of physiology and anatomy displayed by many of its teachers and advocates.

CHAPTER II.

PLAYS, GAMES AND ATHLETICS.

38. The remarkable conservatism existing in the educational world, because of which there is so much retained today of the means and methods in vogue in the Jesuistic schools of the middle ages to the exclusion of physical and manual training, is partly due to a common misconception of the true nature of these important activities and partly to the lack of preparation of teachers for the newer lines of work. The public must be rightly informed as to the meaning and value of play before it can be used as the best educators approve without the schools being condemned for "faddism" and frivolity. The popular conception of play differs little from the idea expressed by Herbert Spencer, that play arises from the rapid chemical activity of the tissues of growing children, and serves as a means of using up surplus energy. Spencer and other scientists have given this as a scientific explanation of the universal tendency of the young to play, and without any intention of implying anything to its discredit; in fact, Spencer has written strongly in favor of play as an educative factor, and would use it to the exclusion of gymnastics and many other kinds of work now in use in the schools. But to the average parent, especially among the industrial classes, the idea of "surplus energy" being thrown off while he has work that might be done with more or less of financial gain, is not pleasing. It is looked upon as a waste of time and strength, which must be put up with as long as the

child lacks the skill and intelligence to do useful work, but which is to be discouraged just as soon as he is able to do something to help earn his living. Later students of play, however, agree in the conclusion that it is due to something more than the need of throwing off surplus energy; that it is an inherited instinct, common to all children and the young of the more intelligent animals, which impels them to the amount and kind of activity that is best calculated to develop and train their immature and growing tissues. According to this view play is not a mere valueless round of movements that serve only to keep the child amused and out of the way until he is old enough to be a help, but youth is a time of exemption from manual labor and self support that the child may play, and through that play develop into a higher type of humanity. The parent who once grasps this conception of the nature of play, and who appreciates the fundamental difference between play and work, will not so eagerly grasp the chance of slight immediate gain at the sacrifice of the opportunity for improvement that ordinary play affords. It is not that play is easier than work,—it is incomparably harder. Play is a constant meeting and conquering of new difficulties, a solving of new and intricate problems, a learning to adapt ones self to new and changing conditions. The work that the child is able to do to advantage is easy, simple, monotonous, and therefore tiresome and depressing. The child needs the inspiration of the new and strange conditions that he constantly meets in his play. How fortunate the child who can keep his play instinct and its associated enthusiasm and use it in his chosen occupation!

39. The teacher who is to teach plays and games successfully must first of all be possessed of the play instinct.

No one who is incapable of keen enjoyment of a lively and active game can do such work well. It is necessary, in order to appreciate the child's view of a game, to have taken part in such a game. To this end the preparation of all teachers, and especially that of special teachers of physical training, should include much of actual practice in gymnastic games. Enthusiasm that has been for a long time dormant often awakes, and the stiff, formal, dignified teacher plays tennis or basket ball with the abandon and zest of childhood. It is good for the teacher and helps her to get nearer to the child life she is to educate. Again, the teacher must be familiar with a large number of plays suitable to the age of the children under her charge,—and by the word "familiar" is meant more than a theoretical idea gained from the reading of the description from a book. The larger practical acquaintance the teacher can have with these plays, the better. To get the child's point of view is essential. The children must be studied as they play, and the play gradually modified to meet the needs that show themselves. Of all things it must be borne in mind that it is the children, not the teacher, who should enjoy the play. How easy for the teacher to have lots of fun while the children merely endure the ordeal! The true teacher readily perceives the feeling of the class, and is guided by it in selection of work and methods of teaching.

40. Simplest of form and best adapted to the youngest children of school age are the *imitative* plays, which are well and abundantly illustrated in the games of the kindergarten. There are imitations of occupations, as when the children imitate the picking of apples from trees overhead and the placing of them in baskets on the ground; of the flight of birds, as in running with arm movements in imita-

tion of the wings; of the movements of the trees and flowers as they sway in the wind and turn to meet the sun. Besides these are the more direct imitation of movements made by the teacher or by a pupil who acts as a leader. Many gymnastic exercises are used in the kindergarten, but they are always given as imitative plays instead of by command, as in higher grades.

A form of play that is always interesting to children is that in which something is thrown through the air and caught. Balls or bean bags are the most common objects used. The history of physical training proves how universal has been the practice and enjoyment of such plays, by old and young, in all parts and ages of the world. The association of more or less running with the practice in throwing, catching, rolling, tossing, bounding and batting a ball gives the greatest possibility for pleasure and general exercise, perhaps, of anything known. The bean bags are cheapest and answer the purpose nicely, but a large, round ball, eight or ten inches in diameter and weighing but a fraction of a pound seems to satisfy best. Such a ball, as well as the bean bags, can be used safely in the school room. A moderate amount of ingenuity will suffice to devise enough ways of using the ball to last a school almost indefinitely. The children do not like too constant a change of play; they will choose the old many times before asking for something new. The general plan should be to select such plays as will call the entire class into action without long waiting by anyone or the monopolizing of the exercise by a few. Simple plays like the following will give recreation of the liveliest kind for a class of primary children:

(1) Pupils standing by their desks or in lines in a room free from desks. The teacher tosses the ball to a pupil,

who tries to catch it, and who throws it back to the teacher. The teacher should throw carefully and try to encourage pupils to learn to use the ball skillfully. It is thrown to one and another at random, thus keeping all watching, with care not to overlook any one. The fastest play possible without losing accuracy of throw is of course advisable.

This simple play admits of a great many modifications that can best be introduced one at a time. The pupil catching the ball may pass it or toss it to any other pupil he chooses, and this pupil throws it back to the teacher; the teacher may choose three or more pupils to stand in front and pupils return the ball to any one of them at will, instead of to the teacher; the pupils throw the ball to one another continually, trying to catch some one napping; the teacher throws to one pupil and calls the name of another, to whom this pupil is to throw, and each one who throws calls the name of the one to receive it next; etc.

(2) The pupils placed as in preceding. The ball is handed to the pupil in front of the first line, and he passes it to the pupils next to him in the same line, and so on down the line. The last pupil in the line runs with the ball to the front and hands it to the first of the second line. In like manner it is passed down each line and carried to the front of the next. The one at the end of the last line carries it to the head of first line and the play continues. Each pupil who runs to front with the ball takes his place at the head of his own line, which moves down one place to make room, and thus every pupil would have a turn at the running.

Variations like the following are suitable:—pupils may pass the ball in several particular ways, rather than in an unrestricted manner, as in the former. Thus, all facing the front, it may be passed over the head, over the right or left shoulder as directed, under right or left arm, or between the feet; the pupils may be placed farther apart and the ball tossed in similar ways, or bounded from one to another, or rolled on the floor; if pupils are eight or ten feet apart each one may toss it to the next by any of these ways, obliging the next one to be on the alert; or each may be required to face, take a step, toss the ball and catch it, or bound it on the floor before tossing it to the next.

Questions and Exercises.—(1) Mention two other variations of play (1), the teacher still taking a leading part. (2) Mention two others in which the teacher directs the play without leading. (3) Mention two others in which the pupils are left to choose the particular place to which the ball is thrown. (4) Mention two other variations of play (2) as to the manner of handling the ball. (5) Two others as to positions of players. (6) Mention other general types of simple play of the same character.

41. With larger pupils the introduction of the competitive element increases the interest and the opportunity for training. The class is divided into two equal groups and the groups compete in various ways. For example: the two groups are placed in two lines of equal length, the pupils in each line being about three feet apart. Two balls are necessary, or, if two balls are not available, two other objects, such as dumb-bells, Indian clubs, or bean bags will answer. The balls are handed to the pupils at the heads of the lines, and when the teacher gives the signal for starting the balls are passed down the lines,—the line passing it to the end first being declared the winner. The pupils at the end hold the balls up as soon as they get them, to show

more plainly who have won. The ball may be passed in any way, but every one must take it in his turn. If any one drops a ball, the same one must take it and pass it on. These three rules,—(1) as to length of lines, (2) as to participation by each player in turn, and (3) as to the dropping of a ball, are all necessary to fair play, and any violation of one of them forfeits the contest to the opposing side.

In modifying this play for variety and increase of difficulty, changes may be made in the positions of the players, in the manner of handling the ball, and the contest may be continued in various ways. For example of these types of changes, the pupils may stand in zigzag lines and six or eight feet apart, in which case the ball may be passed as before by each one running to the next, or by tossing it or bounding it. As the ball reaches the end the contest may be continued by the end players rolling it back to the head or running to the head with it and starting it again. In these cases the same rules as before will apply.

It is evident that all such contests should have simple rules that should be clear and definite as to (1) restrictions upon the positions or movement of players, (2) restrictions upon the manner of handling the ball, and (3) penalties. Any new rules that are made necessary by modifications in the contests should be made carefully with the view of encouraging skilful play, providing against unfairness or chance of injury, and making the play increase gradually in difficulty. Penalties should be severe enough to encourage the right kind of play, but not so severe as to lessen the interest in the play. To make a child leave the play because of a mistake or even a foul, is too severe. Only wilful misconduct merits such a penalty. It is equally evident that the rules should be understood by all at the outset and should be strictly and impartially enforced. Along with the competition in skill and quickness comes the temptation to win by unfair means, and for this reason the teacher must be on the alert to see every play and apply the penalty promptly for every foul. By emphasizing the value of skill and dexterity, teaching the pupils how to make good plays, etc., the teacher can hold the spirit of emulation up to a high plane. Poor teaching and indifferent umpiring may encourage discourtesy, selfishness and fraud. Competitive plays, well conducted, train children in habits of right conduct, and bring them to realize that the highest pleasure can be reached only when the rights of all are fully respected and when courtesy and good will prevail. Such training may be more efficient for the formation of a high standard of character than all the sermons, all the mottoes, and all the stories with a moral. It may serve as the best possible form of recreation that is to be had in the school room.

Questions and exercises: (1) Mention five variations of the above competitive play, made by changing the positions of the players. (2) Mention five variations in the manner of handling the ball. (3) Mention five ways of continuing the contest when the ball has passed to every pupil on the side. (4) Teach to the class and umpire a contest of this type.

42. Another change and a noticeable advance is made when the players, instead of doing some definite thing dictated by the rules, are given an object to accomplish by methods of their own choosing or according to circumstances. Here we have, for the first time, what may be called a *game*. Besides the activities employed in the competitive plays there is exercise of judgment and decision. There are two

types of games,—one, like circle ball, having one player who is known as "it," and who is pitted against all the rest until he accomplishes what is required; and one, like base ball, having an equal number of players on each side. The latter is the higher and more advanced type, as it may involve the form of cooperation known as "team play." In games the umpiring is necessarily as important a matter as in competitive plays, and is usually much more difficult to do. Even so simple a game as circle ball requires the utmost of the umpire's attention, and then there are frequently decisions to be made about which there might be difference of opinion. Right here is an important element of training. The pupils must learn by experience that the teacher is to be trusted to make careful and impartial decisions, and at the same time they must learn that it is the umpire who must decide, even if it looks as if a particular decision is wrong. The chances are that the umpire knows best, and even if he is mistaken, as is likely to occur once in a while with the best of umpires, it is not to anyone's advantage that he should accept a player's opinion instead of his own. If the teacher rightly directs the thought of the pupils, they will not fall into the habit of thinking that winning is the only object, but will enjoy the play and the helpful work of the teacher as well as the winning of games.

Circle ball, which has been mentioned as an example of the first type of games, is a game calling for a good deal of activity and ingenuity. The players stand in a circle, except one who stands in the center. The players in the circle toss the ball from one to another, and the one in the center tries to get at it or to touch a player while he has it. If he touches one who has it, that one has to take his place in the center. If he gets the ball, the one who touched it last must go in the center.

Examples of the second type of games that are useful for school purposes are Newcomb and basquet.

In Newcomb a line is drawn across the floor at the middle and on each side of this and six or seven feet from it are two other lines called base lines. The part of the floor between the base lines is neutral ground, and the other two parts the places of the two teams. The ball is thrown back and forth, the object of each team being to make the ball strike the floor in the opponent's territory and to prevent it from striking in their own. It is a foul to touch the floor in the neutral ground or to throw the ball so that it strikes there. The score is kept by counting one for every time the ball strikes the floor in the opponents' territory and one for every foul made by an opponent. The first team to gain ten scores wins the game. To begin the game the ball is tossed up over the center line, and two players, one from each side, jump for it and try to bat it with the open hand toward their own players. The team toward which the ball goes has the first throw. Sometimes it is necessary to call a foul when the ball strikes a wall, as strong players are able to make throws in that way that are very difficult to stop. In case players throw too swiftly, a cord can be stretched across the room over the center line and six feet high, calling all balls foul that go under the cord. The game affords opportunity for the most simple team-play, since different players must occupy certain parts of the floor and so coöperate in defeating the attempts of the opponents. This game is often played in the school room among the desks with good success, but it is necessarily lacking in vigor and activity in such quarters. It can also be played out of doors, with lines to enclose the playing space.

In basquet there is a basket at each end of the room, at a height of eight or ten feet, and the floor is divided into as many rectangular spaces as there are players on a team. Each of these spaces should be not less than ten nor more than twenty feet square. The players are paired off according to ability, a player and his opponent occupying each of the spaces. The object of each team is to put the ball in their own basket as many times as possible during the time of play, and to prevent the opposing team from so doing. The game is started as in Newcomb, and the ball is advanced toward the basket by being thrown from one player to another. The players must not touch the ball while outside of their respective spaces, and must not drop the ball. The opponents may try to intercept the ball, but no pushing or other rough or dangerous play is permitted.

This is the typical form of basquet, but the name applies also to all forms of basket ball in which the movement of players over the floor is restricted by boundary lines. The form that has been so popular at the Michigan State Normal College gymnasium has nine players on a team and three divisions of the floor. The main points of all these games have been borrowed or modified from the Y. M. C. A. game of Basket Ball, which has achieved world wide popularity, but which is too violent for children and also for all of the non-athletic class of persons. It is also a dangerous game for beginners, although those skilled in it avoid injury without difficulty. The use of dividing lines in the basquet games prevents massing of players, which is apt to result in collisions and falls of serious character, but at the same time it limits the chances of team-play. The forfeit of the ball whenever it strikes the floor compels skilful throwing and catching rather than the helter skelter scramble on the floor that always occurs when beginners attempt the Y. M. C. A. game. There are various sets of rules used for these games at the different schools and colleges where they are played, and these can usually be had in printed form from the teacher of Physical Training.

The great variation that is sure to occur in the situations and problems appearing to a player of a game makes it unnecessary that the teacher should be familiar with such a variety of games that is necessary in the case of the simpler plays. It is of greatest importance that the teacher shall have a very thorough acquaintance with a few games of the best kind. Such games well taught will increase in popularity as greater proficiency is acquired. Since they call for so much freedom of action, games are less suited to the school room, where desks and other furniture offer more serious hindrance than in plays. Besides the proficiency in the games to be used with her own school the teacher should not fail to make herself familiar with a few of the standard games that have stood the test of centuries. Football, baseball and tennis, all of which are closely related to games in common used in the Middle Ages, are classics that are worth the time spent in learning them by all who hope to use games as a means of education.

QUESTIONS AND EXERCISES.—(1) What are the principal objections to football as a school game? (2) To baseball? (3) To tennis? (4) What would you give as the four most essential qualities of a good game for school use? (5) Umpire a game of Newcomb. (6) Umpire a game of basquet, as played in the M. S. N. C. gymnasium. (7) What advantages has Newcomb over basquet? (8) What advantages has basquet over Newcomb? (9) Describe four forms of play that could be used to advantage as preparation for basquet. (10) What are the main points to be kept in mind in guarding a player who has the ball? (11) In guarding a player who wishes to get the ball from one of his own team? (12) What is the general principle as to the best place to throw a ball, so that a player who is guarded by an opponent may get it? (13) What is the general principle to follow in trying to catch a ball thrown to you when an opponent guards you? (14) What are the main advantages of a running game, in playing basquet? (15) What are the main advantages of a stand still game? (16) Select from the lists of games given in the books of reference the three best games you can find for school use.

43. Athletic games and contests differ from the plays and games already considered in (1) the intensity of the competition, (2) the severity of the exercise, and (3) the period of special preparation preceding the contest. The chance of winning a gold or diamond trophy or of gaining wide notoriety by making or breaking a record, together with the excitement existing at the time of contest, results in every competitor exerting himself to his utmost in his effort to beat some one, and, if possible, every one. The preparatory training, intended to put the athlete in the best bodily condition possible, involves special attention for several weeks to exercise, diet, bathing, sleep, and other hygienic matters. This is the part of athletics which, from the hygenic and educational standpoint, is most valuable. The contest itself is apt to be an excessive strain, involving liability to serious injury, but it is a necessary evil, as it is the stimulus to the training. The injuries received in athletic games and contests are principally in

cases of contestants whose training has been insufficient or faulty, or of players who are too light for the places they try to fill on a team. Intelligent management of athletics by competent teachers can eliminate these evils almost completely. The trouble has been that athletic work has been managed and directed by inexperiencd boys who think of nothing but to win, and left to their management by the school and college authorities, who have been too much in sympathy with mediæval methods and subjects of education to appreciate and work out the best possibilities of such training.

REFERENCES.—Strachan, Spencer, Blow, Groos, Tsanoff, Alumni of B. S. N. G., Johnston, Cassell, Youth's Cyclopædia, Mind and Body, Stoneroad, Y. M. C. A. Ath. League, Camp.

CHAPTER III.

GYMNASTICS.

43. The Swedish syetem of gymnastics is unique in several particulars, but most of all in the use of a common lesson plan, which is known as the "day's order." It provides that every lesson in gymnastics shall consist of a prescribed number of groups of movements, each of which has a prescribed purpose, given in a prescribed order. The following lesson may serve as an example:

LESSON 1:

1. Foot placing forward. Foot placing backward. Foot placing sidewise.
2. Marking time. Marching.
3. Head bending backward.
4. Arm raising sideways. Arm raising forward. Wing position.
5. Standing on toes. The same in stride position,—in walk (b) position.
6. Trunk bending forward, taken from wing stride position.
7. Trunk bending backward, from sitting position, with foot support.
8. Trunk bending sidewise.
9. Running in place.
10. Marching.
11. Arm raising sidewise, with deep breathing.

By insisting upon reducing all gymnastic material to the above form, and by rejecting all that does not readily adapt itself to this form, the Swedish system has laid itself liable to the charge of narrowness and exclusiveness. There is also difference of opinion as to some of the principles upon which the "day's order" is based. If one were to restrict himself in his teaching to a single system, these would be serious objections, but for one who wishes to learn the principles underlying all systems of educational gymnastics, the Swedish lesson has decided advantages as a point at which to begin the study of the subject. It is an illustration of a definite policy based upon definite principles, and exemplifies principles of teaching that are accepted by all qualified teachers as well as those which are peculiar to the system.

The prominence given to the "day's order" emphasizes first of all that *a gymnastic lesson should be planned.* No more serious charge can be made against a lesson than aimlessness. Any teacher with a passable understanding of the meaning of education will try to work for some definite purposes. Without this teaching is wholly lacking in character and value.

The Swedish lesson also emphasizes the fact, so apt to be unnoticed or forgotten by the average teacher, and completely ignored by some teachers with hobbies, that *physical training exists for the accomplishment of several distinct purposes, and consequently includes several kinds of exercises.* No teacher of today would think of giving an adequate mental training by the use ot but one kind of work; there are even more definite and visible reasons who physical training requires many kinds of work. It appears upon the school program as one of the least important single subjects of study, while in reality it includes a whole curriculum of different subjects. The small time allowed the teacher for physical training does not at all relieve him of the duty of considering the various purposes and means that its nature demands.

The first two groups of exercises in the "day's order" are preliminary, aiming chiefly to prepare the way for what is to follow. The next seven groups form the lesson proper, and gradually increase in muscular requirement up to the ninth, which is the climax of the lesson. The last two are intended to bring the body back gradually to the quiet condition. The more detailed explanation of the plan is as follows:

(1) Order movements. Pupils coming to class from various accupations are not in the mental condition most favorable for gymnastic work. The exercises, chosen and taught with the object of securing the attention of the class quickly, demand strict attention to commands and accuracy of movement and rythm. As the first work of the lesson, they should require but a small amount of muscular effort. Since the repetition of one movement continuously, known in gymnastics as "series work," tends quickly to become reflex, such exercises are not good for gaining the attention, and order movements are always in the form of "command work." Typical examples of order movements are: facings, alignments, numbering, opening and closing order, etc. Since the mental element is prominent in all new exercises this group is a suitable place for the teaching of any new exercise that does not fall plainly in some other group. The order movements of the lesson given are examples of this kind. Another mental condition as necessary to good gymnastic work as attention to the work in hand is a feeling of confidence in one's ability to do what is required. For this reason it is important that a class shall not be dis-

couraged at the outset by too difficult combinations. Order movements should begin with easy exercises, and increase in difficulty as they are successfully executed.

A number of persons, principally physicians, who have done much for the cause of physical training, make strong objection to the use of any such exercises as these, on the ground that they only add to the mental discipline which the child has already received to excess in his other work. From the standpoint of the physician, who stands outside of the school system, this sounds plausible; but when we consider that in most cases the gymnastic work is taught by the same teacher who gives the mental discipline, its absurdity appears. The exercises used for physical training afford a means of securing some kinds of mental training more easily, efficiently, and with less of strain upon the child than by the usual subjects of study. Unless something of accuracy is required and advancement made, neither pupils nor teachers will respect the subject, as the fate of the Dio Lewis movement shows. If the pupils are suffering from excess of requirements, let the excess be corrected where it exists, rather than cripple one subject that another may have more than its just share of attention. More than all that, there is a hygienic quality in self-control, a possible acquisition of power to hold one's impulses in check, that can be gained from this very kind of gymnastic exercises better than in any other way. Besides, there is the moral influence of habits of prompt and ready obedience that is not to be left out of account. The idea that physical training should never aim to be more than a dose of medicine to counteract evils that the teacher continues to impose upon the children deserves less credit than it has received.

(2) Leg movements. These are designed to give a moderate stimulation of the heart and respiration, to draw the blood in greater quantities to the muscles, and to produce the general change commonly spoken of as "warming up." Since we wish a considerable amount of work without much effort or fatigue, we find the most suitable material in marching and other series work for the large muscle groups. Command work does not have enough rapidity for this purpose. Among suitable movements are change of feet from the different walk positions, heel raising, knee bending, etc. There is evidence of a common belief in the use of such exercises in the practice of all athletes in immediate preparation for a game or contest.

(3) Strain-bendings, or arch-flexions. These are bendings of the trunk in the upper thoracic and cervical regions for the purpose of correcting round shoulders and lifting up the chest. The well-known tendency of school life to the development of this fault of posture, together with its serious interference with respiration, is the reason given by the Swedes for daily use of this group. Considering the large percentage of deaths from lung diseases, the point seems to be well taken. Head bending and trunk bending backward, the movement being limited to the two regions mentioned, are the most typical exercises. Variation in this group is limited, the change of the position in which the exercise is taken, and the combining of it with arm movements, being the usual changes. As there is difficulty in localizing the movement in the proper part of the spine, it is often taken "with support," as a means of learning it more quickly.

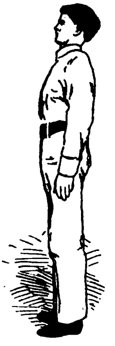

Fig. 25. Head bending backwar A typ cal strain-bending.

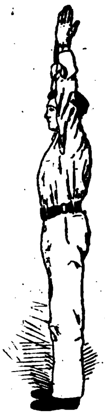

Fig. 26. Arm extension upward. A typical heave movement.

(4) Heave movements are such movements of the arms as tend to expand the chest. The typical example of this group is suspension by the hands, as in the exercises on the rings, climbing, etc. Large muscles passing from the arm and shoulder to the ribs are brought into use in these movements, exerting an upward pull on the ribs and thus enlarging the chest. Since suspension exercises are too severe for some persons, and as the necessary apparatus is not to be had in most school rooms, milder arm movements having a similar effect are substituted. Arm raising and stretching are common examples.

(5) Balance movements, in which a position involving unstable equilibrium is taken and held for a time, help to improve the general posture and cultivate ability to control the body in difficult positions. The number of accidents resulting from imperfect control of the body, and resulting in severe and sometimes fatal injury, point to the practical importance of this phase of physical training. The amount of training in balance that an exercise gives depends fully as much upon the manner in which it is taken as upon the selection of the movement. Heel raising, for example, if taken slow enough or held long enough, is a mild balance movement, but if taken more rapidly it loses all of its character as a balance movement and with sufficient increase of rapidity becomes a typical exercise of group 2.

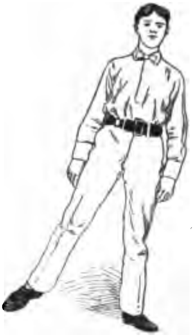

Fig. 27. Leg raising sidewise. A typical balance movement.

Groups 6, 7 and 8 are movements for the back, abdominal and side muscles respectively, and consist of forward, backward, and sidewise bendings in the order given. They give mild work for these muscles before the more severe work of the next group, and stimulate the internal organs by the alternate pressure and relaxation. The abdominal exercises are taken preferably in sitting position, as a backward bending of the character required cannot be taken in standing position without hollowing the back and tending to flatten the chest. After pupils have had training in group 3 sufficiently to be able to retain the chest in proper position, the movement may be taken in standing position. By equalizing the strength of the trunk muscles, these exercises have a beneficial effect upon posture.

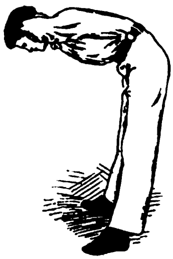

Fig. 28.
Trunk bending forward-downward. A typical back movement.

(9) This is the climax of the lesson. The work should be the strongest and most difficult of all. Such exercises as jumping, vaulting, and active games are the best examples. Where games and apparatus work cannot be used, running and jumping are the usual substitutes. Failure at this point is one of the most common faults of school gymnastics. The lesson so often contains nothing to satisfy the pupils' natural craving for vigorous movement demanding speed and agility, as well as other qualities, and the work is often disliked for this very reason.

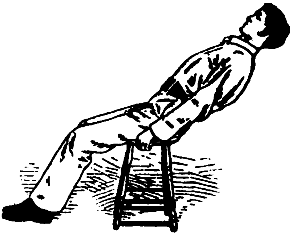

Fig. 29.
Trunk extension backward from sitting position. A typical abdominal exercise.

(10) Slow leg movements. In case the preceding group

is carried to such a degree of vigor as to produce a rapid heart rate and labored breathing, such movements as slow marching are used to quiet the system. The pumping action of the rythmical movements upon the veins is thought to aid the heart in catching up with its work. This theory and the use of this group of movements for the purpose given are ridiculed by some teachers, but it corresponds closely with what has been the practice of athletes and horse trainers since the earliest times, and agrees with the common experience that the discomfort attending excessive muscular work is less if one keeps moving than if he stops suddenly, and the after effects are less severe. It is of course absurd to give exercises for this purpose if they are not needed.

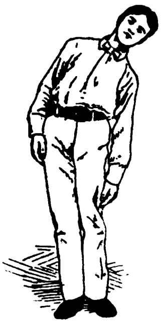
Fig. 30.
Trunk bending sidewise. A typical side movement.

(11) Breathing exercises. These are deep, voluntary respirations, accompanied by arm movements that aid in chest expansion. They have a marked quieting effect, and are less likely to produce dizziness and other undesirable results if taken after the exercise of the lesson than if taken at the beginning.

The lesson given as an example is intended for pupils of grammar grade and for a class period of twenty minutes or a half hour. For primary pupils the work must be modified to meet the different physical conditions, which have been referred to in another chapter. In case the class period is shorter, it will be necessary either to devote less time to each group in turn, or to give only a part of a day's order at a lesson. The short time usually allotted to the subject compels a sacrifice of efficiency in one direction or another. It is in the highest degree desirable that several distinct types of bodily exercise should be given, whether one accepts the Swedish plan or not. It is at the same time more conducive to interest and enjoyment to have a logical progression from one exercise to another which immediately follows it, than to have no logical relation between the parts of the lesson. A choice of plan which avoids as much as possible of both difficulties is all the teacher can do under such conditions. Twenty or thirty minutes three times a week is better as far as these two points are concerned than a shorter daily period, and is for this reason to be preferred with pupils above the seventh grade. Such an arrangement of the time for gymnastics is also advisable to a certain extent in lower grades, if enough time is allowed for recreative plays and games besides. If the gymnastic exercises are all the physical training the children are permitted to have, they must be given more often.

Lessons in gymnastics should be so planned as to give a constant and easy progression, each exercise that is mastered being followed by another related to it but with a slight advance in strength or skill or both. Is a set of Swedish lessons this progression is necessarily between the exercises of the groups rather than between the lessons. The following lesson, designed to follow the first example given, will illustrate.

1. 1 step forward. 1 step backward. 1 step sidewise. Alignment forward.
2. Marching.
3. Head bending backward, from wing position.
4. Arm flinging sidewise. Arm flinging forward. Bend position.

5. Toe standing, in stride and walk(b) positions, with arms sidewise. Same with arms forward.
6. Trunk bending forward, from bend stride position.
7. Repeat movement of preceding lesson.
8. Trunk bending sidewise from wing stride position.
9. Running in place.
10. Marching.
11. Arm raising forward, with deep breathing.

At this point it is worth while for the student to become familiar with the names of the fundamental Swedish positions, and the abbreviations that are used in writing lesson plans. The general descriptions of the movements given in the two lessons already outlined are too inexact and take up too much room for regular use. In the following set of lessons the two preceding are given in abbreviated forms, and two others added to further illustrate progression.

LESSON I.

1. Wk(b), forward. Wk(b), backw. Std.
2. Mark t. Mch.
3. Bow.
4. Cr(c) (i). Rch (i). Wg.
5. T. Std, T. Wk(b), T.
6. Std, pr.
7. Sit, F sup, Tr ext b.
8. T r b s.
9. Run pl.
10. Mch.
11. Cr(c) br

LESSON II.

1. 1 st f. 1 st b. 1 st s. Al f.
2. Mch. (work for exact rythm.)
3. Wg, bow.
4. Cr(c) (ii). Rch (ii). Bd.
5. Cr(c) std, T. Rch wk(b), T.
6. Bd std, pr.
7. Review.
8. Wg std, Tr b s.
9. Review.
10. Review.
11. Rch br.

LESSON III.

1. 2 st f. 2 st b. Wk (b), F ch.
2. Mch. (faster time).
3. Wg wk(b), bow.
4. Bd, cr (c).
5. Std, T, cr(c), wg, rch.
6. Std, pr, cr (c) & wg.
7. Review.
8. Rch std, Tr b s.
9. Run.
10. Review.
11. Cr(c) br.

LESSON IV.

1. r fc.
2. Wg wk (b), F ch. T.
3. Cr(c) wk(b), bow.
4. Cr(c) (iii).
5. T, K b.
6. Rch std, pr.
7. Review.
8. Cr (c) std, Tr b s.
9. Review.
10. Review.
11. Rch br.

Questions and Exercises:—(1) Trace the progression in each group through these four lessons. (2) What examples are found of new movements not related to anything preceding? (3) What examples of movements related to others previously taught in another group? (4) How explain the transfer of T from group 5 in lessons I, II, and III, to group 2 in lesson IV? (5) Can you find examples in the lessons of new movements that should be analyzed in the teaching? (6) Give examples of movements in these lessons that cannot be analyzed with any advantage. (7) What is the general manner of securing progression in the trunk bending of groups 3, 6, and 8? (8) Explain the different significance of periods and commas when used in abbreviations of exercises. What is meant when no punctuation mark is used between the parts? (9) Make out two other lessons following the four given above. (10) Make lists of exercises suitable for the different groups, from which to select in making out other lessons. (11) Arrange this material in progressive order in each group.

54. Drills and exhibitions are commonly and rightly condemned as a hindrance to regular work and an extra strain upon pupils and teachers. Exhibitions are usually objectionable because they usually consist of something entirely foreign to the regular work of the school and are undertaken at the last moment, when they necessarily take

an undue amount of time and attention. An exhibit of physical training should show what the pupils have worked upon regularly, in order to interest the public in the actual work and give them a right idea of it. By planning as carefully as other lines of school work are planned, the gymnastics may be brought to a climax at the end of a term, and then an exhibition can be given with little or no extra effort, and it will strengthen and stimulate the work of the whole term. In order to make the exercises attracive it is not necessary to sacrifice anything of their value. In drills of free gymnastics, or exercises with wands or dumb bells, the Swedish day's Order can be carried out in full if desired. Two drills are given as illustrations. In drills with clubs, or of fancy steps, or some other kinds of work, it would not be easy to fulfil all the requirements ol an all around lesson, and the daily practice can be supplemented by some other kind of work that gives what is lacking. The physiological requirements should determine first of all the general character of the work. Then, if the teacher will use her ingenuity to interest the pupils, and get them to do it well, it will not fail to interest the public.

DUMB BELL DRILL.

1. March on floor two abreast, halt, open order by side steps, place bells on chest. (Each part taken at a chord.)

2. (1) Thrust upward and raise heels, (2) sink arms to cr(c) and knees bend, (3) return to position of (1), (4) return bells to chest and heels sink. (March time, each part at one count. Taken 8 times.)

3. (1) Thurst forward and head bending backward, (2) swing arms to cr(c), (3) return arms to rch, (4) raise

head and place bells on chest. (Slow waltz time, each movement taking four measures. Taken 4 times.)

4. (1) Thrust r bell up and l bell down, (2) return to chest, (3) thrust l up and r down, (4) return to chest, (5) strike overhead, (6) strike behind hips, (7) strike at rch, (8) return to chest. (March time, each part at one count. Taken four times.)

5. (1) Thrust forward and raise r foot forward, (2) swing arms to cr(c) and swing foot sidewise, (3) swing arms up and swing foot backward, (4) return to starting position. (Slow waltz time, each part taking four measures. Repeat with other foot, then repeat both.)

6. (1) Chop with both hands, (2) return to chest, (3) thrust up and look at bells, (4) return to chest. (Waltz time. One measure for each part. Taken 8 times.)

8. (1) Thrust r up and l down and l foot sidewise, (2) bend trunk l and bend l knee, (3) return to position of (1), (4) return to starting position. (Waltz time. One measure for each part. Repeat on other side, and take 4 times.)

9. (1) R fal(a) and anvil stroke on r knee, (2) turn about on balls of feet, sway to l fal(a) and anvil stroke on l knee, (4) return to position of (1), (4) return to starting position. (Waltz time, one measure for each movement, repeat on l side. Taken four times.)

10. Hands at sides, close order, march down center, lines separate and pass back on sides of room, come up center single file, halt when in single file down center of room.

11. Raise arms forward upward with deep breathing, sink sidewise downward with exhaling. No music. Taken 4 times. Exhale silently the first time, with a hissing sound second, whistling third, and give the school yell or some appropriate cheer on the fourth.

WAND DRILL.

Class on floor in open order, wands in "carry" position.

I. Practice, by command, selections from the manual of arms, as given in the Army Regulations. Finish with wand down in front.

2. In four parts. (1) Entire class take forward swing and step position forward, right and left alternately, (2) entire class take sidewise vertical swing and step position sidewise bending other knee right and left alternately, (3) numbers one take (1) while numbers two take (2), (4) numbers one take (2) while numbers two take (1). (Slow march or polka or fast waltz time. Each movement taken 8 times.)

3. Swing wand forward upward and bend head backward, lower wand on shoulders, raise wand again, return to starting position. (Slow waltz time, four measures for each movement. Taken 4 times.)

4. In four parts. (1) Entire class take forward thrust and turn, right hand and left hand being up in alternation, (2) Swing sidewise vertical, swing overhead, swing to other side vertical, swing down, taken in succession by whole class, starting to right, (3) numbers one take (1) while numbers two take (2), (4) numbers one take (2) while numbers two take (1). (Time like preceding. The first thrusting movement must be taken from the downward position of wand and the first swinging movement from the chest. Each taken 8 times.)

5. In four parts. (1) Entire class swing wand right horizontal and raise left leg sidewise, (2) entire class swing wand forward upward and raise heels, (3) numbers one take (1) while numbers two take (2), (4) numbers one take (2) while numbers two take (1). (Slow waltz time, four measures for each movement, each taken four times.)

6 and 8. In four parts. (1) Entire class swing wand forward upward and place right foot sidewise, swing wand to insteps, swing up overhead again, return to starting point, (2) entire class swing wand to shoulders and step right foot sidewise, bend trunk to right, raise trunk, return to starting position, (3) numbers one take (1) while numbers two take (2), (4) numbers one take (2) while numbers two take (1). (Waltz or slow polka time, one measure for each movement. Alternate right and left 4 times.)

9. Combination of sidewise vertical swing with sidewise fallout in same direction, with advancing. Taken to right as far as room permits, reverse as far as room permits, to right again to center of room. Then numbers one start to right and numbers two to left, reversing and finishing as before. (Slow polka or common waltz time, one measure for each movement.)

10. Carry wand, close order, march down center of room, divide right and left, march up sides of room, come down center single file, spiral march, finish in a large circle.

11. Raise arms sidewise and breathe, taken 4 times.

Questions and Exercises.—(1) Which group of the day's order do simple dumb bell exercises most closely resemble? (2) Which group do simple wand exercises most resemble? (3) Club exercises? Fancy steps? (4) Which group seems to be most difficult to supply with dumb bell exercises? (5) Which is given to excess? (5) Make out two lessons to stand at the beginning of a list that would prepare a class to give the above dumb bell drill. (7) Same for the wand drill. (7) What kind of work will best supplement club exercises? Marching? (9) Give four ways of grouping a class in drills, so as to increase the interest of the class and the effectiveness of the drill.

45. Even of greater importance than the planning of lessons is the work of the teacher in the conducting of the class. In gymnastics, as in all subjects for which no outside study is required, everything depends upon the teacher as she stands before the class. Interest must be created and sustained without the help of books or illustrative material. Three or four points are especially worthy of attention.

First of all there is a trial of the teacher's ability to teach new exercises. The rate of advancement and consequently the interest of the class depend to a remarkable degree upon the skill with which the exercises are presented. There is necessitated an exceptional fullness and accuracy of knowledge on the part of the teacher. since no helps are to be had. Then, the teaching must be concrete and objective. Talking about exercises is not enough. The movement must be shown, and its important details pointed out *while it is before the eyes of the pupils.* Consideration of the manner in which one learns a new movement will convince one of the importance of giving a clear and vivid idea of the movement to be learned. Practice should follow this presentation of the movement as closely as possible, and to this end all complex movements should be analyzed by the teacher and presented and practiced in parts. Before practice has continued long it is necessary to point out mistakes, that pupils may rightly compare their own movements with the given one and thus gradually eliminate their faults. The custom of standing constantly before the class and leading in all the exercises is not good teaching, because it fails to inform pupils of where their movements are wrong. Criticism that usurps the time for practice is equally bad. A clear idea to begin with, strengthened by frequent showing of the exercise; practice repeated again and again; and comparison of the exercise made with the correct one, are all absolutely essential to the best teaching and the most rapid advancement. The purpose of the work indicates that of all things the practice should not suffer.

Another matter of importance is the giving of commands. There are a few mechanical details in giving commands that can be and should be completely mastered by every teacher. The typical command includes (1) an explanatory part, which should give all necessary information of what is to be done; (2) a pause, long enough to allow full comprehension of what has been said: and (3) an executive part, which is the signal for action. The explanatory part should be spoken in a clear, animated tone, at the speed of ordinary conversation. The executive part should be distinct, vigorous (not necessarily loud), and with slightly rising inflection. A perfect command requires in addition to all this a clear, strong, and pleasant voice, an animated and encouraging tone, showing at the same time a thorough interest and purpose in the work, and sufficient flexibility to prevent monotony.

A duty more difficult of performance than either the efficient teaching of new exercises or the giving of faultless commands is the ready and accurate criticism of the gymnastic work of classes. Thorough familiarity with the subject is considered essential in ordinary studies, where the teacher has to criticise the work of individuals; but it is much more essential where he has to correct or commend the work of whole classes acting in unison. First will occur common mistakes which need to be pointed out to the class as a whole, and then individual mistakes that must be detected and corrected. Criticism, like the presentation of new work, must be clear, to the point, specific and objective. A general statement that one's work is not correct, without any intimation as to just what is wrong, is worse than no criticism, because discouraging and not helpful. It is also important to avoid confusing pupils with a multitude of minute details at once.

The ideal which is held up before the class in the way of requirements has a wonderful influence upon the efficiency of the teaching. One who demands prompt obedience to all commands, a fair degree of accuracy in movement and rythm, a good standing position, and the avoidance of movements not called for, and who insists upon having all these things all the time with unruffled patience and ceaseless persistence, will get just what he requires. It will not do for to assume that pupils will always do well the old and familiar exercises, nor to lose temper when they do less well than might be expected. Constant watchfulness and strictness without scolding or favoritism are necessary, in order to keep gymnastic work up to a high standard.

QUESTIONS AND EXERCISES:—(1) Into what parts would you analyze right face in teaching it to a class of grammar grade? A1 s? fal (a)? Mch? Rst? (2) Teach the following exercises to the class as illustration of how you would present them to beginners: bd,— 1 st f,— wk(b),F ch,— mch to rear,— wand swing s vert,—ab fc. (3) Give the commands for the exercises of the third and fourth lessons given in the text to a small class of persons who know the movements. (4) Point out the mistakes made in the class while some one else gives the commands. (5) Teach a lesson of your own planning to a small class, giving two of the exercises as if new to the class, and make all needed criticism of the work. (6) Give to a class who know the exercises a series of dumb bell movements involving at least four changes, and give the commands for the changes so as to neither stop the class nor interrupt the rythm. The following series will illustrate: thr r bell s in series, thr 1 bell s in series, r and 1 alt, both at same time, r bell up in series, 1 bell same, r and l alt, both, r bell f, 1 bell f, r and l alt, both. (7) Give commands similarly for a series of club exercises. (8) Same for a series of wand exercises. (9) Of what advantage is musical accompaniment to gymnastic exercises? (10) When is the music not of advantage? (11) Name several different things that may serve as a time signal. (12) What will serve best as a time signal to help a class get the rythm of a new exercise? (13) What characteristics must exercise have in order to best develop muscular strength? Give examples. (14) What in order to develop the heart? Give examples. (15) What in order to develop endurance? Examples. (16) What in order to develop alertness and agility? Examples.

TABLE OF DEFINITIONS OF ELEMENTARY GYMNASTIC MOVEMENTS.

COMMANDS AND ABBREVIATIONS ALPHABETICALLY ARRANGED.

[Technical names of movements and positions are given in Capitals, and commands in Italics.]

NOTE.—It was hoped that by the time of publication a uniform list of elementary movements and commands would be recommended by a committee of the American Association for the Advancement of physical Education which was appointed for that purpose. In the absence of this report, which has been postponed, the use of terms that we have come to find most satisfactory in our work is given. The German form of command has often been given, even in case of Swedish exercises, as it is more complete and satisfactory. Facings and marching movements are given according to the U. S. Army Infantry regulations. This list is small, but attempt has been made to give a fair selection of the best work. Abbreviations used in the lists of exercises are also defined.

A, Arms.

About, Face! See facings.

ALIGNMENT FORWARD. (Al f). Command, *Class forward, Dress!* The class should be in one or more files. Movement quick as possible. All except the leaders raise arms forward, measure distance by touching the next in front lightly on the sides of the shoulders with the hands, and stand directly behind the next one in front. Command, *Arms, Down!*

ALIGNMENT SIDEWISE. (Al. s). The class being arranged in one or more ranks, command, *Class right, Dress!* in three parts taken together as quickly as possibly. Ist, all in front rank place 1 hand on hip, and all guides except the first take al f. 2d, all in front rank except the guide move sidewise until the r arm touches l elbow of next neighbor, and all in other ranks stand directly behind them. 3d, all except the guides glance to right and stand in exact line with those on the right. Command, *Eyes. Front!* All hands drop quickly to side and all eyes turn to the front.

Al f, alignment forward.

Al s, alignment sidewise.

Alt, alternately.

ANVIL STROKE, a movement with dumb bells, in which one bell is held still to represent the anvil while the other bell strikes it.

ARM CIRCUMDUCTION, arms raise forward upward and sink sidewise downward. See str.

ARM PARTING, separation of the arms from str or rch to cr(c).

Attention! see fundamental standing position.

b, backward, or bend.

bd, bend position.

backward-outward, half way between backward and sidewise; diagonally at 45°.

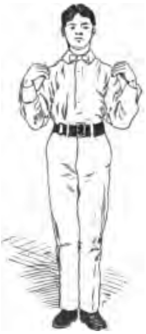

Fig. 31. Bend.

bd, bend position.

Bells on chest, Place! See position of bells for thrusting.

Bells on hips, Place! The hands grasping the bells are brought quickly to the hips, the knuckles resting against the crest of the hip bone. Return command, *Bells, down!*

BEND. (bd). Command, *Bend arms upward, Bend!* Moderate speed. Elbows completely flexed, and held close to sides. Hands half closed, brought over the shoulders, and held as far back as possible. Return command, *Arms, Down!* (A fairly strong heave movement). Figs. 31 and 43.

b-o, backward-outward.

BOW. (i) Command, *Bend head backward, Bend!* Slow movement. Head held erect and moved directly backward, chin drawn in, chest high. Return command, *Head, Raise!* (ii) Command, *Bend trunk backward, Bend!* Same as (i) except that the movement is more pronounced and the spine is bent backward as far as the middle of the chest,—not lower. (The typical strain-bend or arch-flexion.) Fig. 25.

Breathing exercises. Voluntary deep breathing, taken with arm movements that aid in inhaling. The usual command for the arm movement is given with the addition of *with breathing* to the explanatory part.

c, crosswise.

Change arms, change! A command given only when the two arms are in different positions. In one count movements, as wg, they are changed in one count, but in stretchings they are brought to bd and then to the changed position.

Change feet, change! A command given only when one foot has been placed out of fundamental position, and meaning that this foot is to be replaced and the other one placed in the corresponding position.

CHOP, a movement with dumb bells, usually taken from V std. Command, *Bells in chop position, Place!* Swing bells forward and downward freely and bend trunk forward and downward freely at the same time, the bells swinging between the knees. Return command, *Bells, Replace!* The movement may be taken with one hand at a time if preferred. When clothing interferes, the arms swing down outside of the knees.

Class, Halt! See marching.

Close order (cl ord). A formation of the class in which the members stand close to each other. The class being in open order, command, *Close order, March!* The spaces are closed first, and then the ranks.

Close Spaces, March! The class or parts of the class beng in the relative positions shown in the diagram, the numbers one and the numbers two take one step which brings them into one line. If the class faces the end of the line the movement is made by side steps, otherwise one group steps forward and the other backward. See *Open spaces.*

1 1 1 1 1 1
2 2 2 2 2 2

Close Ranks, March! The class being in the form shown in the diagram, the two lines take two steps toward each other, thus bringing the class into close order. See *Open ranks.*

1 2 1 2 1 2 1 2 1 2

1 2 1 2 1 2 1 2 1 2

Club Swinging, see swings.

Clubs in position, Place! From fundamental position the hands holding the clubs are brought up quickly to a vertical position in front of and close to the shoulders, top of club about as high as top of head, knob of club being held in the hand. Return command, *Clubs, Down!*

Counting by the class is to be used as a help in learning the rythm of a new movement. Add *with counting* to the usual command of explanation.

Count twos, Start! See numbering.

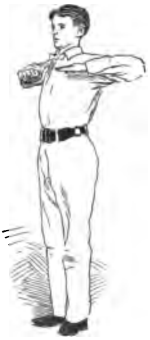

Fig. 32.
Cross (a).

Cross(a). (cr(a). Command, *Bend arms forward, Bend!* Moderate speed. The elbows are completely flexed, raised to the height of the shoulders, and carried as far back as possible. Forearms horizontal, wrists and fingers straight, palms down. Return command, *Arms, Down!* (A heave movement. Fig. 32.)

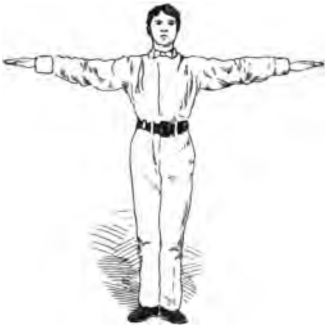

Fig. 33. Cross (c).

CROSS(C). (cr(c). (i) Command, *Raise arms sidewise, Raise!* Slow movement. The arms are raised sidewise to a horizontal position, elbows straight, palms down. Return command, *Arms slowly, Sink!* (ii) Command, *Fling arms sidewise, Fling!* Same as (i) but as quick as possible. Return command, *Fling arms downward, Fling!* (iii) Command, *Stretch arms sidewise, Stretch!* Two counts. 1st, take bd; 2nd, straighten arms quickly sidewise to position described under (i). Return command, *Stretch arms downward, Stretch!* (Mild heave movement. Fig. 33.)

(ii) may be taken from cr(a).

CROSS(E). (cr(e)). Command, *Bend arms half upward, Bend!* Moderate speed. The upper arms are as in cr (c). The elbows are flexed to a right angle, forearms vertical, wrists and fingers straight, palms toward head. Return command, *Arms, Down!* (An order movement, also having some value as a heave movement. Fig. 34.)

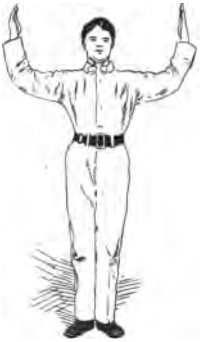

Fig. 34. Cross (e).

d, downward.

Dumb bell exercises, see thrusts, swings, strokes, chop, etc.

f, forward.

Facings. Movements made by turning on one heel as a pivot. (i) (r fc). Command, *Face to right, Face!* Movement in two parts. 1st, raise the right toe and the left heel and turn to right 90 degrees by pushing with the left toe. 2nd, place left foot in position beside the right. (ii) (ab fc) Command, *Face about, Face!* Precisely like (i) except that a turn of 180 degrees is made. (iii) (l fc) Command, *Face to left, Face!* Similar to (i), taken in opposite direction by changing the movements executed by the feet. (The facings are order movements.)

Fallout(A). (fal(a)). Command, *Right* (or left) *outward, Fallout!* The movement is like the fal (b), which is more elementary, except that it is taken in the diagonal direction indicated by the command. See outward. The face and shoulders are toward the front, not turned.

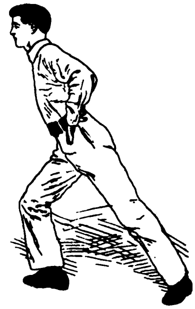
Fig. 35.
Fallout (B).

Fallout (B). (fal (b)). Command, *Right* (or left) *forward, Fallout!* The foot is raised and moved forward three foot-lengths, forward knee flexed until it is directly above the toe, body and rear limb inclined forward and straight from head to heel, heels resting on the floor, toes turned out as in fundamental position, face and shoulders toward the front. Return command, *Foot, Replace!* or *Rear foot, Advance!* Fig. 35.

Feet sidewise, Place! See stride.

File, a line of persons standing one behind another.

Fling, a command of execution for certain quick movements of the arms. See cross (c), rch, str.

Follow, a form of club swings in which one club follows the other. Any of the parallel swings may be changed to follows by having one club lead by about ¼ of a revolution. See also mill wheels.

Foot placing, see stride, walk (a), and walk (b).

Forward dress, see alignment forward.

Forward, March! See marching.

Forward, Jump! See jumping.

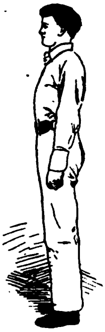

Fig. 36. Fundamental position.

FUNDAMENTAL POSITION. (Pos). Fig. 36. Command, *Attention!* or *Position!* To be taken quickly. Heels together, toes turned out to form a right angle, knees straight, hips straight, trunk erect, chest high, head erect, chin held in, shoulder held back and down at same level, arms hanging freely at sides (not in front), fingers and wrists straight (not stiff), eyes to the front. Return command. *Rest!* or *In place, Rest!*

Guide, the one of a line who is taken as the basis of alignment, usually at the end.

Guide, Right! A command given while a class is marching in ranks, meaning, to glance to the right and correct the alignment while marching, using the one at right end as guide.

H, head, or heels.

Half, a term often prefixed to the name of a movement to indicate a modification in which only one arm or one leg is used where the usual movement uses both. Thus, half standing means standing on one foot, half str means stretch one arm upward, half wing half rest means that one arm is to take one position and one the other. The sign ½ is often used in the same sense. See one-half.

Half-facings, an exception to the above rule, in which the meaning is that the facing is taken as usual with a turn of 45 instead of 90 deg.

Halt, see marching.

Hands, Turn! A command for twisting of arms in pos. rch, cr(c), or other positions, with or without bells.

Head bending, see bow.

Heels, Raise! See toe.

HOOK (A). A position hanging by the hands, the knees being raised to the level of the hips and flexed to a right angle, ankles extended. When taken in this way it is an abdominal exercise. Commands, *Hands overhead, Grasp! Knees upward, Bend! Knees, Sink! Hands, Down!*

HOOK (B). From hook (a). Command, *Stretch knees forward, Stretch!* The knees are straightened as far as possible without allowing them to sink. In half kook (b), taken from half hook (a),the commands and movement are similar.

hor, horizontal.

JUMPING (jp). (i) Command, *Jump upward, Start!* A movement in six counts. 1st, raise heels; 2d, bend knees; 3d, jump; 4th, alight on toes with knees bent; 5th, stretch knees; 6th, sink heels. (ii) Command, *Jump forwurd, Start!* Movement like (i), except that the jump is taken forward instead of directly upward. (iii) Command, *Jump sidewise to the right* (or 1), *Start!* Like (i), but toward the side. Jumps are varied by introducing a turn of 90 or more degrees while in the air, or by preceding the jump with one or more running steps. The command is the same as before with the addition of *with turn of 90 degrees to right*, etc., to the explanatory part. When starting steps are used they take the place of parts 1st and 2d, in the above definition, so that a jump with one start step takes but five counts, K, knees.

K b, knee bend position.

KNEE BEND (K b). Command, *Bend knees, Bend!* Usually taken from T. Moderate speed. The knees are flexed to a right angle and turned outward at the same angle as the toes. The heels are necessarily lifted. Trunk is held erect. Return command, *Knees, Stretch!* (A balance movement. Fig. 37).

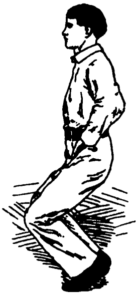

Fig. 37.
Knees bend.

Knees bend forward, see hook (a).

KNEELING POSITION. (Kneel). Command. *Bend knees to kneeling position, Bend!*

Large circles, see swings.

l, left.

L. leg.

l fc, left face. See facings.

Leg raising, see ½ standing position.

MARCHING (mch). Command, *Forward, March!* Begin with the left foot, take steps of three foot-lengths in even rythm, and continue until another command is given. At the command, *Class, halt!* one additional step is taken, and on the second count the rear foot is brought into position beside the other. Upon reaching a wall or other obstacle that cannot be passed, the class should mark time until a command is given.

MARCHING TO REAR. (mch rr). Command, *To the rear, March!* At the command *march,* given as the right foot touches the floor, 1st, take one step with the left foot, placing the foot directly in front of the right; 2d, lift the heels and turn 180 degrees to the right on the balls of the feet; 3d, begin marching in the opposite direction. Marching to the right (mch r) and marching to the left (mch l) are commanded and executed similarly. The march to right is like the one given except that the foot is placed outward instead of across and the turn is 90 degrees. In march to left the command is given at the same time, but two steps are taken before turning, and the first step of the march in the new direction is with the right foot.

MARCH STEPS. (i) Command, *One step forward, March!* 1st, take wk (b) with l foot; 2d, bring r foot up into position. (ii) Command, *One step backward, March!* 1st, take wk(b) backward with left foot; 2d, bring r foot back into position. Two steps forward and backward, also a larger number in either direction, are commanded and executed in a similar way.

MARKING TIME (m t). Command, *Mark time, Mark!* Beginning with the left, the feet are lifted alternately and moved forward half their length, then replaced. Uniform rythm is kept as in marching, and the halt is commanded and executed as in marching.

Mch, marching.

Mch l, march to left.

Mch rr, march to rear.

Mch r, march to right.

MILL WHEEL, a club exercise in follow time.

Neck, Firm! See rest.

NUMBERING (num). Command, *Number by ones and twos, Start!* Taken only when the class stands in one or more ranks. Each guide on the right turns his head to left and says, "One!" the next in line turns his head in the same way and says, "Two," the next, "One!" the next, "Two!" and so on to the end of the lines. The lines may count together, or the front line count alone, the others taking numbers by listening. Numbering by threes, fours, etc., is done in the same way.

o, outward.

½, see half.

½ HOOK (A). (½ hk (a)). Command, *Right* (or l) *knee upward, Bend!* The knee is raised and the limb placed in the same position as in hook (a). Return command, *Foot, Replace!* (A balance movement. Fig. 38).

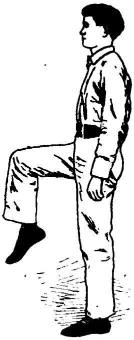

Fig. 38.
½ hook (a).

½ HOOK (B). (½ hk (b)). Taken only from ½ hk (a). Command, *Stretch knee forward, Stretch!* The thigh is held in position of ½ hk (a) while the knee is extended as far as possible, ankle extended. Return command, *Knee, Bend!*

½ KNEELING POSITION. (½ kneel). From wk (b). Command, *Bend knees to half kneeling position, Bend!*

½ STANDING POSITION. (½ st pos). (i) Command, *Raise right leg sidewise, Raise!* Slow movement. Foot is lifted and raised sidewise, knee straight, until it is two foot-lengths from the other, trunk erect. Fig. 27. Return command, *Foot, Replace!* (ii) Command, *Raise right leg forward, Raise!* (iii) Command, *Raise right leg backward, Raise!* (Balance movements.)

One step backward. (1 st b). See march steps.

One step forward. (1 st f). See march steps.

One side step. (1 s st). See side steps.

OPEN ORDER, (op ord). A formation of the class to give increased room for movements. Command, *Open order, March!* The ranks are opened and then the spaces.

Open ranks, March! The class being in two ranks standing close together, as given by al s, the ranks take two steps away from other. See close ranks.

Open spaces, March! The class being in ranks, each of which consists of alternate numbers one and two, the numbers one take a step forward and the numbers two take a step backward. If the class is in files, side steps are taken, ones to r and twos to l. See close spaces.

OPPOSITE SWINGS. Club exercises in which the circles described are in opposite directions, as both sidewise or both across.

Outward, in a diagonal direction midway between forward and sidewise.

PARALLEL SWINGS. Club exercises in which the circles described are parallel, as both to right or left.

Parting of Arms, One! Two! see arm parting.

Position! See fundamental position.

Position of bells for chops, strokes, thrusts, etc., (V). Command, *Bells on chest, Placc!* Place bells quickly on chest in the form of the letter V, lower ends almost touching, elbows close to sides. Return command, *Bells, Down!*

Position of clubs, see clubs.

Position of wand. (i) For marching. Command, *Wand in carry position, Place!* Wand carried vertical in right hand, close to body, wands at uniform height in the class, held lightly. (ii) For swings. From carry position, command, *Wand downward, Placel* 1st, left hand grasps wand in front of right shoulder, 2nd wand placed horizontally in front of thighs, arms straight, knuckles forward, hands as far apart as shoulders. (iii) For thrusts. Command, *Wand on chest, Place!* From position for swings command, *Wand on chest, Place!* Flex elbows and bring wand quickly against the chest. (iv) For twists. Command, *Wand in position for* *twists, Place!* Wand placed down as for swings except that the palms are forward.

PREPARATION FOR JUMPING. (pr jp). *Preparation for jumping, Start!* 1st raise heels, 2nd, bend knees, 3rd, stretch knees, 4th, sink heels.

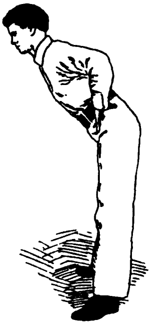

Fig.39. Prone.

PRONE. (pr). Command, *Bend trunk forward, Bend!* Slow movement, located in the hip joints. Bend as far as possible without bending the trunk. Return command, *Trunk, Raise!* Fig. 39.

PRONE FALL. Command, *hands on the floor and feet backward, Place!* 1st, bend quickly and place hands on the floor in front of toes, 2nd, place feet backward, trunk and limbs fully extended, making a straight line from head to heels. Return command, *Feet forward and, Stand!* (Abdominal exercise.)

r, right.

Raise, a command for slow movements upward of arms, legs or trunks. See Cr(c), rch, str, ½ st pos, bow, pr, stp, etc.

RANKS, lines in which the persons stand side by side.

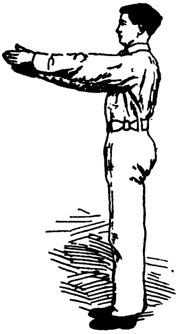

Fig. 40. Reach.

REACH. (rch). Fig. 40. (i) Command, *Raise arms forward, Raise!* Arms raised slowly forward to horizontal position, palms toward each other, arms straignt and parallel. Return command, *Arms, Down!* (ii) Command, *Fling arms forward, Fling!* Same as preceding, but quick as possible. (iii) Command, *Stretch arms forward, Stretch!* 1st, execute bd, 2nd, straighten arms quickly to position of (i) and (ii). Return command, *Stretch arms downward, Stretch!*

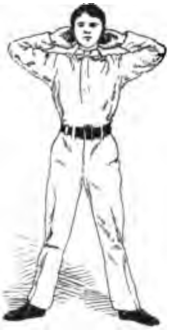

Fig. 41.
Rest stride.

REST. (Rst). (Figs. 28 and 41). Command, *Neck, Firm!* Quick movement. The hands are raised and placed behind the neck, finger tips touching each other and the neck. Elbows well back, head erect. Return command, *Arms, Down!*

Right face, see facings.

ro, rotation, a twisting on pivot, as head otation.

RUN. *Run forward, Start!* Start with left foot and keep uniform rythm until another command is given. The movent should be light and elastic. the heels kept off the floor. At the command, *Class, Halt!* come to fundamental position at end of four counts.

Run in place, Start! Movement executed like running, but no progress is made. Halting is commanded and executed similarly.

s, sidewise.

Series. (ser). This means the continuous repitition of an exercise until another command is given. The usual command of an explanation is given with the addition of *in series, Start!* To stop the series command, *Class, Halt!*

SIDE STEP. (s st). Command, *One side step to right, March!* 1st, execute std (i) with r foot, 2d, place l foot in position.

Sink, return command to correspond to *raise.*

Sitting position, a position sitting upon a seat, chair, bench, or the floor, preparatory to certain movements, especially Tr ext b.

sl, slowly.

Small circles, see swings.

Start steps, running steps preceding a jump for distance. See jumps.

STEP POSITION. A movement similar to std (i) except that no weight is placed upon the foot that is moved. The floor is tapped briskly with the toe at a distance of two foot-lengths, usually forward or sidewise. The command *Right foot in step position sidewise, Place!* Commonly used in combination with wand and dumb bell movements, where the std is sometimes too slow.

STRETCH. (str). Fig. 26. (i) Command, *Raise arms forward upward, Raise!* Start as in rch (i) and continue slowly up to vertical position, palms toward each other, arms straight and parallel The arms may be allowed to slant sidewise, but not forward. (ii) Command, *Fling arms forward upward, Fling!* Same as preceding but quick as possible. (iii) Command, *Stretch arms upward, Stretch!* 1st, execute bend; 2d, straighten arms quickly to position of (i) and (ii). Return command, *Stretch arms downward, Stretch!* (Strong heave movement.)

STRIDE (std). Fig. 41. (i) Command, *Place right foot* (or l foot), *sidewise, Place!* Quick movement. The foot is moved two foot-lengths directly to the side and the weight is equally divided at once. Return command, *Foot, Replace!* (ii) Command, *Place feet sidewise, Place!* The left foot is placed one foot-length to left on first count, and the right one foot-length to right on second count. Return command, *Feet together, Place!* (Order movement.)

Stroke, a dumb bell movement in which the bells are struck together. The usual places for striking bells are in front of thighs, behind body, over head, over insteps, behind knees, and under chin. They may be struck in almost any position desired and commanded. The usual form of command is, *Strike bells over head, Strike!* The arms swing freely through as large an arc as possible.

Support, a form of assistance in certain Swedish exercises, mainly bow and Tr ext b, helping the pupil or making the work more difficult, as the need may be. The most elementary form of support for bow is the support of the back of the school seat. Support by the hand in the middle thoracic region is a help, while support at the back of the head is used in advance work to increase the resistance. Support for Tr ext b is for the feet, to prevent the balance being lost. Fig. 29.

SWINGS with clubs. The elementary swings are the sidewise and crosswise swings, large and small. The large circles are full arm swings. The small circles are circles of the club about the hand, made by movement of the wrist and arm. Small circles are made 1st, behind the shoulder; 2d, in front of thigh; 3d, behind hip; 4th, in front of shoulder. They are best learned in the order named. 1st, with r hand sidewise; 2d, l hand sidewise; 3d, r hand crosswise; 4th, l hand crosswise; 5th, both to right, parallel; 6th, both to left, parallel; 7th, both sidewise; 8th, both crosswise. Form of command, *Right club sidewise, Swing!*

SWINGS with wands. These are mostly straight arm movements, which are named and commanded from their final positions. The most common are 1st, forward—just level with the shoulders; 2d, overhead; 3d, on shoulders, passing through the overhead position; 4th, sidewise horizontal in which one arm is straight and the other bend to a right angle, both horizontal; 5th, sidewise vertical, in which one arm is vertical and the other as in 4th. Common form of command, *Swing wand forward, Swing! Wand, Down!*

TOE. (T). Command, *Raise heels, Raise!* Rise on balls of feet and stand motionless. Return command, *Heels, Sink!*

THRUSTS with bells. (thr). Taken from V. Command, *Thrust right bell sidewise, Thrust!* Place thumb on ball of bell, turn bell in line with arm, thrust arm quickly sidewise horizontal and twist it to turn the knuckles forward. Return command, *Bell, Replace!* Thrusts are made similarly forward, upward and downward, and combined alternately and at same time.

THRUSTS with wands. (thr). Taken from position for wand thrusts. Command, *Thrust wand forward, Thrust!* Arms straightened forcibly forward. Return command, *Wand on chest, Place!* The wand is also thrust upward, downward and in other ways, in similar manner, and by similar command.

Tr, trunk.

TRUNK BENDINGS. Slow movements of the trunk. For bending back, see bow and Tr ext b. For bending forward, see pr. Sidewise bending, command, *Bend trunk to right* (or left) *Bend!* The bending is directly to the side, with head and shoulders in fundamental position with reference to the trunk. Return command, *Trunk, Raise!* (Fig. 31.)

Trunk extension backward from sitting position. (Tr ext b) Command, *Trunk extension backward, One! Two!* The first executive command is for the backward movement and the second for the return. (Abdominal exercise. May also be taken from kneel or ½ kneel). (Fig. 29.)

TWISTS of bells. Movements made by rotation of the forearm or wholearm, the bells being turned first one way and then the other.

TWIST of wand. Taken from position of twists. Command, *Twist right arm downward, Twist!* The right hand is close to end of wand, and holds it tightly. The left hand allows the wand to slip freely. Raise wand forward, then bend right elbow and pass right hand down between wand and body. Return command, *Wand, Replaced!* Starting in same way the twist may be completed in several different positions, most easily sidewise horizontal, diagonal forward upward, and vertically behind back.

TWIST of trunk. (tw). Command, *Twist trunk to right, Twist!* The trunk only is twisted. By trying to twist the hips in the opposite direction at the same time they may be kept in fundamental position. Return command, *Twist trunk forward, Twist!* (Fig. 42.)

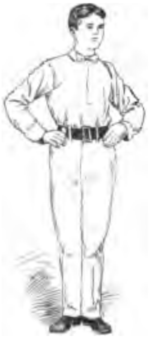
Fig. 42.
Twist of Trunk.

u, upward.

V, bells on chest, the position of bells for thrusting.

vert, vertical.

WALK (A), (wk(a)). (i) Command, *Place right* (or l) *foot outward, Place!* The foot is raised and moved two foot-lengths outward (see outward) and the weight equally divided. (ii) Command, *Place right* (or l) *foot backward outward, Place!* Same distance in the backward outward direction. Return command, *Foot, Replace!*

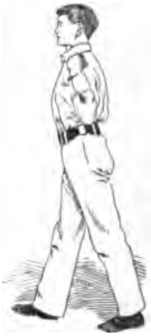
Fig. 43.
Bend walk (b).

WALK (B). (Wk(b)). Fig. 43. (i) Command, *Place right* (or l) *foot forward, Place!* Foot is raised and moved two foot-lengths directly forward, toes turned out at same angle as in fund pos, and the weight is equally divided.

(ii) Command *Place right* (or 1) *foot backward, Place!* Foot moved backward same distance. Return command, *Foot, Replace!*

Wand exercises, see swings, thrusts, and twists.

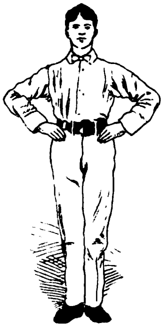

Fig. 44. Wing.

WING. (wg). Fig. 44. Command. *Hips, Firm!* Quick movement. Hands placed firmly against trunk just above hips. Palms rest against crest of hip bone, fingers forward. Elbows slightly backward, wrists either straight or slightly below the line of arm and hand. Return command, *Arms, Down!*

REFERENCES:—Posse, (1), (2) and (3), Ballin, Stecher, Enebuske, U. S. Infantry Drill Regulations, Nissen, Harvey, Bancroft, Anderson.

APPENDIX.

AN OUTLINE OF APPLIED ANATOMY, FOR THE USE OF STUDENTS OF PHYSICAL TRAINING.

By consulting some reliable work on Anatomy the student should become familiar with the following terms:

I. TERMS RELATING TO THE BONES.

Periosteum, compact tissue, cancellous tissue, Haversian canals, lamellæ, lacunæ, canaliculi, lines of pressure, bone cells, marrow, shaft, head, epiphysis, condyle, process, fossa, spine, tuberosity, tubercle, foramen.

II. TERMS RELATING TO THE ARTICULATIONS.

Articular surface, cartilage, synovial membrane, synovial fluid, ligament, arthrodial, hinge, ball and socket, pivot, amphiarthrosis, flexion, extension, adduction, abduction, circumduction, rotation.

III. TERMS RELATING TO MUSCLES.

Contractile tissue, connective tissue, sheath, fasciculus, muscle fiber, tendon, aponeurosis, fascia, origin, insertion, contraction.

Muscles of equal size have varying power and range of movement, due to different arrangements of the fibers. These arrangements are called (1) *longitudinal* and (2) *penniform.* Their differences of structure and action should be fully understood.

The bones of the body act as a system of levers, the muscles serving as the power, the joints as fulcrum, and the resistance to the movement corresponds to the weight. All three classes of levers are found, but those of the first and third classes are most common. The question as to how the leverage affects power and range of movement should be fully understood.

There are four different ways of determining the action of a muscle.

1. By observing upon the mounted skeleton the places of attachment, the fulcrum, and other mechanical conditions.
2. By feeling the hardening of the muscle upon the living body during voluntary movement.
3. By direct stimulation of the muscle by electricity.
4. By observing what movements are lost in cases of partial paralysis or atrophy.

Muscles serving to hold the fulcrum or the origin in place during a movement are called supporting muscles. Those used to direct a movement, like the reins on a horse, are called guides. Muscles acting in opposite directions are called antagonists.

(Each bone, articulation, and muscle should be studied from skeleton, manikin, and one or more of the large works on Anatomy.

THE UPPER LIMB.

The upper limb includes shoulder, arm, forearm, wrist and hand.

I. THE BONES. The dimensions of the large bones should be found with rule or tape. As clear an idea as possible of the general shape of each should be gained by observation of the skeleton, accompanied by reading descriptions in the texts.

1. Clavicle,—superior and inferior surfaces, anterior and posterior borders.

2. Scapula,—internal and external surfaces; superior, vertebral and axillary borders; inferior, superior, and exterior angles; spine; coracoid and acromion processes; glenoid cavity; supraspinous fossa.

3. Humerus,—head, shaft, inner and outer condyles and condyloid ridges, greater and lesser tuberosities, bicipital groove.

4. Ulna,—head, shaft, greater and lesser sigmoid cavities; coronoid, olecranon and styloid processes.

5. Radius,—head, shaft, bicipital tuberosity, styloid process.

6. The eight carpal bones, in two rows of four bones each.

7. Five metacarpal bones.

8. Fourteen phalanges.

II. THE ARTICULATIONS.

1. Sterno-Clavicular.—This is a double arthrodial joint, the bones being separated by an interarticular cartilage, with one articulation between clavicle and cartilage and another between cartilage and sternum.

Ligaments, (1) interclavicular, joining the clavicles, (2) costo-clavicular, from clavicles to cartilage of first ribs, (3) capsular, enclosing the joint.

Movements of the clavicle at this joint, (1) upward, (2) downward, (3) forward, (4) backward, (5) circumduction.

2. Scapulo-clavicular.—Arthrodial joint, outer end of clavicle articulating with acromion process of scapula.

Ligaments, (1) capsular, (2) coraco-clavicular, the latter having two parts called conoid and trapezoid.

Movements, (1) gliding movement, (2) slight rotation.

Through the movements of the two articulations just described the scapula is allowed a wide range of movement upon the surface of the chest. *The movements of the Scapula* are (1) adduction, toward the spinal column, (2) abduction, from the spinal column; (3) elevation, (4) depression, (5) rotation, raising the shoulder; (6) rotation, depressing the shoulder. The clavicle and scapula do not move independently.

Accompanying the study of the articulations the muscles will be studied.

Muscles attached to scapula and clavicle.

1 *Trapezius.*

Origin,—occipital bone, ligament of the neck, spines of the 7th cervical and all the thoracic vertebræ.

Insertion,—outer third of posterior border of clavicle, top of acromion, upper border of spine of scapula.

Structure,—the fibers from clavicle and acromion pass upward, those from the greater part of the spine of the scapula pass inward, and those from the lower end of the spine of the scapula radiate inward and downward.

Action,—the upper third of the muscle tends to elevate the scapula and rotate it, throwing the shoulder upward; the middle third, to adduct it; the lower third to adduct and depress it. The whole muscle acting together is a powerful adductor and rotator, raising the shoulder.

2 *Levator anguli scapulæ.*

Origin, —transverse process of the four upper cervical vertebræ.

Insertion,—vertebral border of scalpula, above the spine.

Structure,—longitudinal fibers.

Action,--to elevate the scapula and rotate to depress the shoulder.

3 *Rhomboid.*

Origin,—spines of the seventh cervical and the four upper thoracic vertebræ.

Insertion,—vertebral border of scapula, below the spine.

Structure,—longitudinal fibers, in two divisions, called the rhomboid major and minor. The minor is above and is much thinner.

Action,—to elevate the scapula, adduct it, and rotate it so as to depress the shoulder.

4 *Subclavius.*

Origin,—first rib, at junction with costal cartilage.

Insertion,—middle half of under surface of clavicle.

Structure,—penniform, radiating from lower attachment.

Action,—to depress the shoulder, and especially to prevent dislocation of the sterno-clavicular joint.

5 *Pectoralis minor.*

Origin,—third, fourth and fifth ribs, near the junction with their cartilages.

Insertion,—coracoid process of scapula.

Action,—to depress, abduct, and rotate the scapula so as to depress the shoulder.

6 *Serratus Magnus.*

Origin,—outer surface of the first nine ribs, at the front and side of the chest.

Insertion,—vertebral border of the scapula.

Structure,—the fibers from the two upper ribs radiate to attach to the entire length of the vertebral border of the scapula. The fibers from the other seven ribs converge and all are inserted at the lower end of the vertebral border. The anterior end of the muscle presents a tooth-like appearance, because of the manner of its attachment to the ribs.

Action,—to abduct the scapula, and because its greater part is attached at the inferior angle, it rotates, to throw the shoulder upward.

QUESTIONS AND EXERCISES.

(1) Chart the movements of the scapula, with the muscles producing each movement.

(2) Chart the actions of the rhomboid, with the antagonists of each movement.

(3) What muscles are used in shrugging the shoulders?

(4) What muscles support a weight on the tip of the shoulder?

(5) With a measuring rod find the amount the width of the shoulders can be changed. What muscles do the work?

(6) Find in the same way the variation possible in the height of the shoulder.

(7) What muscles are at fault when there is a deep hollow between the scapulæ on the back?

(8) When the shoulders are too far forward?

III. SCAPULO-HUMERAL, OR SHOULDER JOINT. The head of the humerus fits loosely in the glenoid cavity, which is deepened by a ring of cartilage, which also serves as a ligament. There is also a cartilage lining the bottom of the cavity.

Ligaments, —(1) capsular, (2) glenoid, (3) glenohumeral, (4) coraco-humeral. The two latter are thickened bands of the capsular ligament.

Movements,—when the arm is carried upward and backward the joint is (1) extended; when it is swung forward it is (2) flexed; when brought toward the body it is (3) adducted; when swung from the body in any direction it is (4) abducted; when swung in a circular manner it is called (5) circumduction; twisting to turn the palm toward the body is (6) rotation inward; twisting to turn the palm away is (7) rotation outward. Abduction is limited to 90 degrees by the striking of the greater tuberosity against the acromion, consquently raising the arm above the horizontal involves upward rotation of the scapula.

1 *Deltoid.*

Origin,—outer third of the anterior border of the clavicle, top of the acromion, lower border of the spine of the scapula.

Insertion,—outer side of the humerus, just above the middle.

Structure,—complex penniform arrangement, fibers converging toward the insertion.

Action,—to abduct the humerus. The anterior part acting along abducts and flexes the shoulder joint; the posterior fibers act chiefly to extend, aiding less in abduction than the anterior and central fibers.

2. *Supra-spinatus.*

Origin,—the supra-spinous fossa.

Insertion,—greater tuberosity of humerus.

Structure,—penniform and converging.

Action,—to abduct the humerus, without influcing the direction of the movement; and especially to hold the head of the humerus in the socket, and thus prevent its being pushed up against the acromion during strong action of the deltoid.

QUESTIONS AND EXERCISES.

(1) Test the strength of the abductors of the humerus with the dynamometer.*

(2) Is the leverage of the deltoid calculated to give speed and range, or power? Why?

(3) Is the arrangement of fibers in the deltoid calculated to give speed and range, or power? Why?

(4) In arm raising sidewise and upward to vertical position, which muscles cause the first half of the movement? The second half?

(5) Do the last mentioned muscles have anything to do during the first half of the movement?

(6) Do the muscles causing the first half have anything to do during the last half?

3. *Pectoralis Major.*

Origin,—inner two-thirds of anterior border of clavicle, whole length of the sternum, cartilages of the ribs from the second to the seventh.

Insertion,—by a flattened tendon to the outer lip of the bicipital groove of the humerus.

Structure,—converging fibers.

Action,—to flex the shoulder joint, rotate it inward, and abduct the scapula. When the arm is raised high overhead it aids powerfully in depressing it, as in lifting the body by the arms or striking with an ax.

4. *Coraco-Brachialis.*

Origin,—coracoid process.

Insertion,—inner side of humerus, near its middle.

Structure,—longitudinal fibers.

---

*Strength is tested by use of the Kellogg mercurial dynamometer.

Action,—flexion and abduction, and to prevent forward and downward dislocation of the shoulder.

QUESTIONS AND EXERCISES.

(1) Test the flexors of the shoulder joint.
(2) What bone serves as fulcrum in this test?
(3) Which way does the humerus tend to push it?
(4) What muscles prevent this movement?

5. *Latissimus Dorsi.*

Origin,—spines of the six lower thoracic and all the lumbar vertebrae, the sacrum, the crest of the ilium, and the three lower ribs.

Insertion,—bottom of the bicipital groove of the humerus.

Structure,—converging fibers. A few fibers attach to the lower angle of the scapula.

Action,—adduction, extension, and inward rotation of the shoulder joint; depression, adduction, and downward rotation of the scapula.

6. *Teres Major.*

Origin,—outer surface of the scapula, at lower end of axillary border.

Insertion,—inner lip of bicipital groove of humerus.

Structure,—longitudinal fibers.

Action,—extension, adduction, and inward rotation of the shoulder joint.

QUESTIONS AND EXERCISES.

(1) Test the extensor group with the dynamometer.
(2) Test the adductor group with the dynamometer.
(3) Tabulate the muscles used in adduction the arm.

(4) Chart the actions of the latissimus dorsi, with the antagonists of each movement.

(5) Which muscles studied thus act upon more than far one joint?

7. *Teres Minor and Infra-spinatus.*

Origin,—outer surface of scapula below the spine.

Insertion,—posterior part of the greater tuberosity of the humerus.

Structure,—longitudinal, slightly converging fibers.

Action,—outward rotation of the humerus.

8. *Subscapularis.*

Origin,—inner surface of the scapula.

Insertion,—lower part of the lesser tuberosity of the humerus.

Structure,—penniform and converging.

Action,—inward rotation of the humerus, and to hold the head of the humerous firmly in the glenoid cavity.

QUESTIONS AND EXERCISES.

(1) Tabulate the rotators of the humerus.

(2) What muscles studied thus far cannot be felt when they contract, because of their being covered with other tissues ?

(3) Which have only one action ?

(4) Mention some kind of exercise or labor that will develop the latissimus dorsi.

(5) The same for the pectoralis major.

(6) When a child is lifted by grasping its arms close to the trunk, which of its muscles support the weight ?

IV. THE ELBOW.—The elbow is a hinge joint, in which the humerus articulates closely with the ulna and slightly with the radius. It has no cartilage.

Movements,—(1) flexion, (2) extension.

MUSCLES.

1. *Triceps.*

Origin,—from three separate heads. The middle or long head arises from the scapula at the lower margin of the glenoid cavity. The internal and external heads arise from the posterior side of the humerus, the former having a broad origin extending over two-lengths of the length of the bone, and the latter a narrower and shorter origin higher up.

Insertion,—by a flattened tendon or aponeurosis into the olecranon process of the ulna.

Structure,—each of the three parts has a penniform arrangement of the fibers.

Action,—to extend the elbow joint. The long head also prevents downward dislocation of the shoulder by holding the head of the humerus up in the socket. This is important in such movements as striking with a heavy sledge, where the sudden stopping of the moving arm tends to tear the shoulder joint apart.

2. *Anconeus.*

Origin,—posterior surface of the outer condyle of the humerus.

Insertion,—upper fourth of the posterior surface of the ulna.

Structure,—fibers radiate in fan shape from the short tendon at the origin, and are inserted directly into the bone.

Action,—to extend the elbow.

QUESTIONS AND EXERCISES.

(1) Test the strength of the extensors of the elbow.

(2) What muscles are employed in pushing a lawn mower ?

(3) In supporting the body by the hands upon the parallel bars?

(4) In striking a blow with the fist?

(5) How many parts or separate movements are there in chopping wood? Name the muscles employed in each.

2. *Biceps.*

Origin,—from two heads. The external or long head arises from the upper edge of the glenoid cavity, and the tendon is blended with the capsular ligament. The internal or short head arises from the coracoid process.

Insertion,—by a common tendon into the bicipital tuberosity of the radius.

Structure,—the fibers diverge from the two tendons of origin and are inserted in a penniform manner into the two sides of the common tendon below.

Action,—to flex the elbow; to supinate the forearm, its tendon wrapping half way round the radius like a rope about a windlass; to hold the head of the humerus in place by means of the two tendons, which pass round the head on both sides.

3. *Brachialis Anticus.*

Origin,—anterior surface of the humerus for more than half its length.

Insertion,—coronoid process of the ulna.

Structure,—fibers arise directly from the surface of the humerus and are inserted in a penniform manner into the tendon which is on the anterior side of the muscle.

Action,—to flex the elbow.

4. *Brachio-radialis.*

Origin,—the external condyloid ridge of the humerus.

Insertion,—styloid process of the radius.

Structure,—fibers arise from surface of humerus and are inserted into tendon in a penniform manner.

Action,—to flex the elbow.

QUESTIONS AND EXERCISES.

(1) Test the strength of the flexors of the elbow.

(2) In making bodily measurements where is the girth of the upper arm taken? What muscles are included?

(3) In the preceding measurement what causes the difference in size as the elbow is flexed and extended?

(4) What muscles are used in the forward movement in rowing a boat?

(5) In the pulling movement?

(6) Which form of lever is exemplified by action of the triceps?

(7) By action of the brachio-radialis?

(8) By the action of the biceps?

(9) Make a list of muscles used to protect the shoulder joint from dislocation.

(10) Name the muscles used in driving a fast horse.

(11) What muscles are used in shooting with bow and arrow?

(12) When the arms are raised sidewise, what muscles are used? when are they lowered to sides again?

(13) Give an instance where the biceps acts during the extension of the elbow.

(14) Give an instance where the triceps acts in flexion of the elbow.

(15) Measure the lever arms on the skeleton and find how much force must be exerted by the biceps acting alone to raise a 16 lb. shot held in the hand.

(16) In the same way how much force the brachio-radialis must exert to raise the same weight.

(17) The same for the triceps.

(18) When will these answers be correct?

(19) What other element besides the length of lever arms must be taken into account in other cases?

(20) Compute the answers for some other position of the joint.

V. Radio-ulnar Union.—We have in the forearm a double pivot joint. The head of the radius rotates in a ring of ligament at the elbow, and the two bones describe semi-circles about each other at the wrist. Since it is the ulna that is hinged to the humerus, and the radius that is hinged to the wrist, the loose union of these two bones allows the hand to be turned freely.

Ligaments,—(1) orbicular, (2) oblique, (3) interosseus membrane, (4) anterior, (5) posterior. (1) and (2) are at the upper and (4) and (5) at lower end of the forearm, while (3) extends the entire length.

Movements,—(1) pronation, turning the palm down, (2) supination, turning the palm up.

MUSCLES.

1 *Pronator Teres.*

Origin,—inner condyle of humerus, front side.
Insertion,—outer side of upper third of the radius.
Structure,—short longitudinal fibers.
Action,—to pronate the forearm.

2 *Pronator Quadratus.*

Origin,—lower fourth of front side of ulna.
Insertion, lower fourth of front side of radius.
Structure,—a thin, flat sheet of longitudinal fibers.

3 *Supinator Brevis.*

Origin—external condyle, ligaments of elbow, rough surface of the ulna below the sigmoid cavity.

Insertion,—upper half of outer surface of the radius.

Structure,—longitudinal fibres.

Action,—to supinate the forearm.

VI. ARTICULATIONS OF THE WRIST AND HAND. The hand is a very complex mechanism, including a large number of joints and muscles. In the time which this course permits we can only notice the movements of flexion and extension which are common to the wrist, hand, fingers and thumb. The wrist admits of overextension, but the hand and fingers do not.

MUSCLES.

1. *The flexor group.*

These muscles, more than a dozen in number, originate from the inner condyle of the humerus, the anterior surfaces of the radius and ulna, and the bones of the palm of the hand. They are inserted into the bones of the palm, and the various joints of the fingers and thumb on the inner side.

2. *The extensor group.*

Originating from outer condyle of humerus, back of radius and ulna, and back of hand, and being inserted into back side of hand, fingers and thumb. The muscles arising from the upper part of the forearm are joined to the hand, etc., by long slender tendons, which are bound into a small space at the wrist by the annular or ring ligament.

QUESTIONS AND EXERCISES.

(1) Test the strength of the pronators.

(2) What other group is tested at the same time?

(3) Test the supinators. What other group is tested this time?

(4) Test the flexors of the hand.

(5) Test the extensors of hand.

(6) Measure girth of elbow, and tell what included in the measurement.

(7) Same for girth of forearm.

(8) Same for girth of wrist.

To analyze a movement, tell (a) what joints are involved, (b) what movements occur, (c) what muscles are employed.

(9) Analyze rest.

(10) Analyze arm stretching upward.

(11) In last exercise, what muscles are made to raise the ribs?

(12) Analyze the act of pulling the handles of overhead pulleys down to front of shoulders.

(13) How does the action on the ribs compare with that in stretch position?

(14) Analyze the action of holding your weight in bent arm position on rings or bar.

(15) How does this differ in action on the ribs from the overhead pulley work?

(16) Compare raising yourself to bent arm position and letting yourself down to straight arm position again with exercise 14.

(17) What muscles are chiefly used in chest weight exercises, back to the machine?

(19) In floor pulley exercises?

(20) What is the characteristic muscular difference between parallel bar and ring exercises?

(21) In what position of a joint does a muscle have the best advantage?

(22) Can a muscle pull most when at full length or when shortened by its own contraction?

THE LOWER LIMB.

The lower limb includes the hip, thigh, leg, and foot.

I. THE BONES.

1. Pelvis.

(1) Ilium,—crest, curved lines, anterior spines, posterior spine, obturator foramen, cotyloid cavity or acetabulum.

(2) Ischium,—tuberosity, spine, sciatic notches, ramus.

(3) Pubes,—crest, ascending ramus, pectineal line.

2. Femur,—head, neck, trochanters, shaft, linea aspera, condyles, condyloid lines, inter-condyloid notch.

3. Patella.

4. Tibia,—head, spine, tuberosities, tubercle, oblique line, shaft, inner malleolus.

5. Fibula, head, shaft, outer malleolus.

6. Seven tarsal bones,—astragalus, os calcis, scaphoid, cuboid, and three cuneiform bones.

7. Five metatarsal bones.

8. Fourteen phalanges.

II. THE ARTICULATIONS.

1. HIP JOINT.—This is a deep ball and socket joint. The head of the femur fits so closely into the cotyloid cavity that it is very seldom dislocated, the bone being fractured close to it much more frequently. The bottom of the cavity is lined with cartilage, and the cotyloid cartilage surrounds and deepens it.

Ligaments,—(1) capsular, (2) transverse, (3) teres, or round. The capsular ligament is strengthened in front by the ilio-femoral band, or inverted Y ligament, which prevents over-extension of the joint, and behind by the ischio-femoral band.

Movements,—(1) flexion, when the knee is carried forward, (2) extension, reverse of flexion, (3) abduction, sidewise movement of the thigh, (4) adduction, (5) circumduction, (6) rotation outward, turning the toes out, (7) rotation inward.

1. *Psoas.*

Origin,—the last thoracic and all the lumbar vertebrae.

Insertion,—lower and back part of the lesser trochanter of the femur.

Structure,—fleshy origin, penniform attachment to long tendon below.

Action,—to flex the hip, and to flex the lumbar portion of the spinal column.

2. *Ilicaus.*

Origin,—inner surface of the ilium.

Insertion,—tendon of psoas, and femur below the lesser trochanter.

Structure,—fleshy origin, converging fibers.

Action,—to flex the hip.

3. *Sartorius.*

Origin,—anterior superior spine of the ilium and part of the notch below it.

Insertion,—front part of inner surface of the tibia, just internal to the tubercle.

Structure,—long parallel strands of fibers extending the whole length of the muscle. It is so strongly attached to the fascia of the thigh that its upper and lower parts can act almost independently. It is the longest muscle in the body.

Action,—to flex the hip; rotate it outward slightly, and flex the knee; the walking muscle.

4. *Pectineus.*

Origin,—front of pubes, below the pectineal line.

Insertion,—back of femur, just behind the lesser trochanter and for two inches below it.

Structure —fleshy above, parallel fibers, tendonous below.

Action,—to flex the hip, adduct it, and rotate it outward.

5. *Rectus Femoris.*

Origin,—anterior inferior spine of the ilium and upper margin of the acetabulum.

Insertion,—upper border of the patella.

Structure,—very strong penniform arrangement.

Action,—to flex the hip and extend the knee.

QUESTIONS AND EXERCISES.

(1) Test the strength of the flexors of the hip.
(2) How exercise these muscles when standing?
(3) In sitting position?
(4) When lying on back?
(5) When hanging by hands?

6. *Gluteus Maximus.*

Origin,—outer surface of the ilium above the first curved line, and outer surface of the sacrum.

Insertion,—rough line leading from the greater trochanter to the linea aspera.

Structure,—fleshy origin, penniform attachment to tendon of insertion.

Action,—to extend the hip. This muscle acts only when the hip is partly flexed, as in climbing stairs, etc.

7. *Semi-tendinosus.*

Origin,—tuberosity of the ischium.

Insertion,—upper part of inner surface of the tibia.

Structure,—longitudinal fibers.

Action,—to extend the hip, and to flex the knee and rotate it inward.

8. *Semi-membranosus.*

Origin,—tuberosity of the ischium.

Insertion,—back and inner side of the inner tuberosity of the tibia.

Structure,—penniform arrangement.

Action,—to extend the hip, and to flex the knee and rotate it inward.

9. *Biceps.*

Origin,—(a) the tuberosity of the ischium, (b) the lower half of the linea aspera.

Insertion,—head of the fibula and outer tuberosity of the tibia.

Structure,—the long head arises by a thin tendon and the fibers leave it in a penniform manner. The short head arises by a thin tendon, and its fibers join the others and enter the lower tendon in a penniform manner.

Action,—to extend the hip, and to flex the knee and rotate it outward.

QUESTIONS AND EXERCISES.

(1) Test the strength of the extensors of the hip.

(2) When the trunk is bent forward while standing

what movement of the hip takes place? What muscles are employed?

(3) Which class of levers are exemplified by the psoas? The rectus femoris, when flexing the hip? The semitendinosus when raising the trunk from stoop position?

(4) What effect has flexion of the knee upon one's ability to flex the hip? Why?

(5) Explain the tendency to incline the trunk forward when bending the knees.

(6) Why is it easier to reach the floor by bending forward than by bending backward?

(7) What muscles have the hardest work in sitting erect on the floor with feet out straight in front? What makes the position difficult?

10. *Gluteus-Medius.*

Origin,—outer surface of the ilium between the first and second curved lines.

Insertion,—greater trochanter.

Structure,—fleshy origin, converging fibers, tendonous insertion. The front portion is much stronger.

Action,—to abduct the hip joint and rotate it inward.

11. *Gluteus Minimus.*

Origin,—outer surface of the ilium, below the second curved line.

Insertion,—greater trochanter.

Structure,—like the preceding.

Action,—like the preceding.

12. *Tensor Vaginæ Femoris.*

Origin,—notch between the anterior spines of the ilium.

Insertion,—the fascia of the thigh, about one-fourth of the way down the outer side.

Structure,—longitudinal fibers.

Action,—to abduct the hip and rotate it inward.

It should be noticed that when the femur is the fixed portion, as in standing on one foot, abduction of the hip consists in raising the opposite side of the pelvis.

13. *Adductor Longus.*

Origin,—pubes, just below the crest.

Insertion,—lower two-thirds of the linea aspera.

Structure,—diverging fibers.

Action,—to adduct and flex the thigh and rotate it outward.

14. *Adductor Brevis.*

Origin,—the pubes, just below and outward from the the preceding.

Insertion,—upper half of the linea aspera.

Structure,—diverging into fan shape.

Action,—to adduct the thigh and rotate it outward.

15. *Adductor Magnus.*

Origin,—the rami of the pubes and ischium on the outer side.

Insertion,—the whole length of the linea aspera and the inner condyloid line.

Structure,—diverging fibers, those from front part of origin passing nearly horizontally to the femur while those from the ischium pass down to the condyle. This forms a flattened sheet which is twisted as it passes down.

Action,—a powerful adductor of the thigh.

16. *Gracilis.*

Origin,—inner edge of descending ramus of pubes.

Insertion,—inner surface of tibia below the tuberosity.

Structure,—a thin flat sheet of converging fibers ending in a flattened tendon.

17. *The Six Outward Rotators.*

These are small muscles arising from the pelvis and inserted into the back side of the femur near the joint. Their action is indicated by the name.

QUESTIONS AND EXERCISES.

(1) Test the abductors of the hip.

(2) Test the adductors.

(3) With the femur as the fixed point, what movement of the pelvis would be produced by the action of the outward rotators? Of the inward rotators?

(4) Which muscles have their work especially increased by standing on one foot?

Analyze the movements of the hip joint in walking.

(6) Analyze ½ hk (a), with sidewise movement of knee.

(7) What are the movements of the hips in rowing a boat? What muscles work?

(8) What muscles and bones are included when girth of hips is measured?

II. THE KNEE JOINT. — This is usually spoken of as a hinge joint, but the shape of the articular surfaces and the manner of the movement are very complicated and unlike those of any other joint in the body. The two condyles articulate separately with two cartilages which rest upon the head of the tibia. The inner condyle is so much the larger that the movement necessitates the sliding of one side faster than the other. The portion of the articular surfaces in contact during extension of the joint is nearly flat, making it easy to stand erect. The back portion of the articular surfaces are curves of small radius. The patella glides over the smooth surface at the front end of the notch between the condyles.

Ligaments,—(1) fibrous expansion from the extensor muscles, (2) anterior, (3) posterior, (4) internal, (5) external, (6) patellar, (7) anterior crucial, (8) posterior crucial, (9) coronary, (10) transverse. The first six of these are called exterior ligaments, as they lie on the outside of the joint, the first five forming the capsule. The last four are within the capsule and are known as the interior ligaments.

Movements, — (1) flexion, ( ) extension, (3) rotation outward, (4) rotation inward. Rotation is only possible when the knee is flexed to an angle of 150 degrees or more.

MUSCLES.

1. *Vastus Externus.*

Outer surface of the femur below the greater trochanter and the upper half of the linea aspera.

Insertion,—patella.

Structure, origin from surface of femur is fleshy and from linea aspera is tendonous. The fibers cross obliquely between the two flat tendons, or from bone to tendon, giving a very powerful penniform muscle.

Action,—to extend the knee.

2. *Vastus Internus and Crureus.*

Origin, - the whole length of the linea aspera and the surface of the shaft of the femus for nearly its entire extent.

Insertion, —patella.

Structure, — like preceding, a strong penniform arrangement.

QUESTIONS AND EXERCISES.

(1) Test the extensors of the knee.

(2) Test the flexors of the knee.

(3) What muscles are included in the measurement of girth of thigh?

(4) Why is it difficult to extend the knee forward from ½ hook (a) position? Two reasons.

(5) Give an instance of flexion of knee with the work done by the extensors.

(6) What muscles acting upon the knee also act upon the hip?

(7) Compare the biceps muscles of upper and lower limbs.

(8) Is there a muscle of the thigh analagous to the triceps?

(9) Compare the olecranon and the patella.

(10) Compare the condyles of femur and humerus. What effect has the relative size of the outer and inner condyles upon the shape of the limbs?

(11) What prevents over-extension of the elbow? of the knees?

(12) Name all the antagonists of the biceps of the thigh.

III. TIBIO-FIBULAR UNION.—These two bones are bound together by ligaments at top and bottom, and connected between the extremities by the inter-osseus membrane. Only a slight gliding movement occurs between them.

IV. ANKLE JOINT.—This is a hinge joint, the tibia resting upon the astralagus, and the malleoli reaching past on the sides.

Ligaments,—(1) anterior, (2) posterior, (3) internal, (4) external. Besides the proper ligaments of the joint, an annular ligament holds the tendons close to the bones.

Movements,—(1) flexion, (2) extension.

V. ARTICULATIONS OF THE FOOT.—Between the tarsal and metatarsal bones and the phalanges there are a large number of articulations that must be passed for lack of time. In general these joints permit of (1) flexion, (2) extension, (3) adduction, (4) abduction of the foot. The largest and strongest of the muscles producing these movements are situated above the ankle, and connect with their insertion by slender tendons. These muscles are as follows:

1. *Gastrocnemius.*

Origin,—by two heads from the back side of the condyles of the femur.

Insertion,—by the tendon of Achilles into the os calcis, or bone of the heel.

Structure,—multipenniform, giving great power.

Action,—to extend the ankle. It also acts somewhat in flexion of the knee.

2. *Soleus.*

Origin,—upper part of posterior surfaces of tibia and fibula.

Insertion,—into the tendon of Achilles.

Structure,—multipenniform.

Action,—to aid the gastronemius in extension of the ankle.

3 *Peroneus Longus.*

Origin,—front side of head of tibia and outer surface of head and shaft of fibula.

Insertion,—first metatarsal and first cuneiform bones, near their union.

Structure,—fleshy origin, penniform junction with tendon, which passes around the outer malleolus as around a pulley, crosses the foot, passing through a groove in the cuboid bone which acts as another pulley, to be inserted at the inner border of the foot.

Action,—to extend the ankle, depress the inner border of the foot, and abduct the foot.

4. Peroneus Brevis arises below the peroneus longus, passes by a slender tendon around the outer malleolus, and is inserted into the fifth meatarsal.

5. Tibialis Posticus, (6) Flexor Longus Hallucis, and (7) Flexor Longus Digitorum arises from the posterior surfaces of the tibia and fibula, pass around the inner malleolus, and are inserted into the scaphoid bone, the great toe, and the other toes respectively.

On the anterior surfaces of the tibia and fibula we have (8) Tibialis Anticus, (9) Extensor Hallucis, and (10) Extensor Longus Digitorum, whose tendons pass under the annular ligament in front of the ankle and are inserted similarly on the top of the foot. The action of these muscles is to flex the ankle and extend the toes.

QUESTIONS AND EXERCISES.

(1) Test the strength of the extensors of the ankle.

(2) Test the flexors of the ankle.

(3) What muscles are included in the measurement of girth of calf?

(4) Explain how the extensors of the knee can help to extend the ankle.

(5) Analyze walking up-stairs.

(6) Analyze pedaling a bicycle.

(7) What is gained by following the pedal around as far as possible with the foot, rather than by pushing straight down upon it?

(8) What is gained by inclining the trunk forward while riding a wheel?

(9) What class of levers is exemplified by the gastrocnemius and soleus extending the ankle?

(10) Why can you bend trunk forward farther from fall-out than from standing position?

(11) Why should the knees be separated in knee bending?

(12) Why cannot deep knee bending be taken without lifting the heels?

THE TRUNK.

The Trunk consists of the neck, chest and abdomen, usually called in Anatomy the cervical, thoracic and lumbar regions.

I. THE BONES.

1. Spinal column—33 vertebræ—body, pedicle, lamina, spinous process, transverse processes, articular processes, neural arch.

(1) Seven cervical vertebræ, normal curve being concave on the back side.

(2) Twelve thoracic vertebræ, normal curve being concave on front side.

(3) Five lumbar vertebræ, normal curve being concave on back side.

(4) Five sacral vertebræ, fused into one bone, which is wedged between the ilia.

(5) Four coccygeal vertebræ, rudimentary.

2. Twelve ribs,—head, neck, angle.
3. Sternum.

II. THE ARTICULATIONS.

1. The Sacrum is bound firmly to the pelvis by strong ligaments on the inner and outer surfaces of the pelvis, and serves as the base upon which the spinal column rests. It has no separate movements.

2. THE ARTICULATIONS BETWEEN THE VERTEBRÆ.—The vertebræ are separated from one another by the intervertebral discs of cartilage, which are firmly attached to the vertebræ, thus forming an amphiarthrosis, or joint moving only by the elasticity of the discs. There are also arthrodial joints between the surfaces of the articular processes.

Ligaments,—(1) anterior and (2) posterior common, (3) subflava, (4) supraspinous. (5) short lateral, (6) interspinous, (7) intertransverse, (8) capsular. The first four are continuous fibrous bands extending the whole length of the spinal column. The next three connect adjacent vertebræ, and the eighth surround the joints between the articular processes.

Movements,—(1) flexion, or bending forward, (2) extension, backward movement as far as normal position, (3) over-extension, backward bending beyond normal position, (4) lateral flexion, (5) rotation. The last is most free in the thoracic region, and the others least free there.

MUSCLES.

The muscles of the trunk may be conveniently divided into four groups, —(1) the muscles of the abdominal walls, (2) the muscles of the back, (3) the anterior muscles of the neck, and (4) the muscles of respiration. This is not an exact division, as the muscles overlap each other, but it will help to get them in mind.

MUSCLES OF THE ABDOMINAL WALL.

1. *Rectus abdominis.*

Origin,—crest of pubes.

Insertion,—cartilages of 5th, 6th and 7th ribs.

Structure, — longitudinal fibers, crossed by three or more tendinous bands. The two muscles do not meet on the median line, but are separated by a narrow strip of connective tissue called the linea alba, which extends the entire length of the abdomen.

Action,—to flex the spinal column and compress the abdominal cavity.

2. *External oblique.*

Origin,—linea alba, crest of pubes, fascia of thigh and crest of ilium.

Insertion,—outer surfaces of the lower eight ribs, at about their middle.

Structure,—the tooth like insertions on the ribs alternate with those of the serratus magnus and the latissimus dorsi. The longitudinal fibers pass downward and inward, and become tendinous before reaching the rectus muscle.

Action,—to flex the spine and compress the abdominal cavity. When one muscle acts alone it rotates the chest to the opposite side, and together with the serratus magnus and rhomboid, twists the spinal column.

3. *Internal oblique.*

Origin,—the fascia of the lumbar region, the crest of the ilium, and Poupart's ligament. The latter is a tendinous band from the anterior end of the crest of the ilium to the crest of the pubes.

Insertion, — crest of pubes, linea alba, cartilages of last three ribs.

Structure,—fibers diverging a little as they pass inward and upward. They become tendinous before reaching the rectus.

Action,—to flex the spine and compress the abdominal cavity. When one muscle acts alone it rotates the chest to the same side.

4. *Transversalis.*

Origin,—lower six ribs, lumbar fascia, crest of ilium.

Insertion,—linea alba.

Structure, — longitudinal fibers passing horizontally inward, becoming tendinous before reaching therectus.

Action,—to compress the abdominal cavity.

MUSCLES OF THE BACK.

This group of muscles is divided for convenience into seven layers, beginning at the surface.

First layer, trapezius.

Second layer, levator anguli scapulæ, rhomboid, and latissimus dorsi.

Third layer, the serrati, which do not concern us at present, as they are muscles of respiration.

Fourth layer, the splenius. This muscle arises from the spines of the upper six thoracic vertebræ and of the lower cervical, and is inserted into the upper cervical vertebræ and the back and side of the occipital bone. It acts to extend the head and neck and to rotate the face to the same side.

Fifth layer, consisting of a group of nearly vertical muscles of great size and importance, beginning with the erector spinæ.

1. *Erector Spinæ.*

Origin,—posterior one-fifth of the crest of the ilium, back of the sacrum, spines of all the lumbar and the 12th thoracic vertebrae. The erector spinæ is not inserted as such, but divided into three parts, designated below as a, b, c.

(2a.) *Ilio-costalis.*

Origin,—it is the outer division of the erector spinæ.

Insertion,—angles of the lower six ribs.

(3a.) *Accessorius.*

Origin,—angles of lower six ribs.

Insertion,—angles of upper six ribs.

(4a.) *Cervicalis Ascendens.*

Origin,—Angles of upper four or five ribs.

Insertion,—transverse processes of fourth, fifth and sixth cervical vertebrae.

Structure,—these three sections form a continuous compound muscle, each fiber extending past five or six ribs.

Action,—to extend the spine and depress the ribs. One side alone will produce lateral flexion.

(2b.) *Longissimus Dorsi.*

Origin,—the middle portion of the erector spinae.

Insertion,—two rows of insertions, one to the transverse processes of the vertebrae towards their bases, and one to the ribs just outside of the vertebrae or to the tips of the transverse processes.

(3b.) *Transversalis colli.*

Origin,—transverse processes of upper six thoracic vertebrae.

Insertion,—transverse processes of cervical vertebrae.

(4b.) *Trachelo-mastoid.*

Origin, — transverse processes of upper four or five thoracic and lower three or four cervical vertebrae.

Insertion, — mastoid process of skull.

Structure,—these three sections of the middle portion of the erector spinae follow the line along the transverse processes, and are closely connected together.

Action,—to extend the spine, and to flex the head and rotate the face to the same side.

(2c.) *Spinalis Dorsi.*

Origin,—inner portion of erector spinae.

Insertion,—spines of the upper thoracic vertebrae.

Structure, — similar to the preceding, but not extending so far upward.

Action, — to extend the spine.

Sixth layer. This consists of a group of muscles whose fibers pass obliquely upward and inward. They fill up the hollows on each side of the spinous processes.

(1a.) *Semispinalis dorsi.*

Origin,—transverse processes of lower thoracic vertebrae.

Insertion,—spines of upper thoracic vertebrae.

(1b.) *Semispinalis colli.*

This is a continuation upward of the same muscle into the cervical region.

Structure,—the fibers pass by from one to four vertebrae before being inserted. The muscle is one continuous sheet throughout its extent.

Action,—to extend the spine, and when one side acts alone, to rotate to the opposite side.

2. *Multifidus Spinæ.*

This is a deeper layer of fibers extending in the same oblique direction. It occupies the entire distance from the sacrum to the second cervical vertebrae.

3. *Rotatores Spinæ.*

These are separate bundles of fibers lying beneath the multifidus and slanting in the same oblique direction. The action of the three muscles of the group is the same. It should be noticed that the muscles of the last two layers differ from all other muscles studied in having an almost continuous series of origins and insertions from end to end. They are thus especially suited to act on the many slightly movable joints of the spine.

Seventh layer. The last layer of the back muscles consists of two sets of vertical fibers, (1) the interspinales, connecting the spines of the adjacent vertebrae, and (2) the intertransversales, connecting the transverse processes. The former extend the spine and the latter flex it laterally, one side acting at a time.

QUESTIONS AND EXERCISES.

(1) Test the strength of the flexors of the trunk.

(2) Of the extensors.

(3) Of the lateral flexors.

(4) What muscles are included in measurement of girth of waist?

(5) What muscles act when the trunk is flexed, from standing position?

(6) From position lying on back?

(7) From position hanging by hands?

(8) In hanging by hands and flexing hip joints, what effect has the weight of the limbs upon the position of the pelvis? What muscles hold the pelvis in position?

(9) What effect has gravitation on the thoracic curve of the spine? What muscles resist the tendency?

(10) Same questions regarding the lumbar curve.

(11) Why does deepening the curves of the spine lessen the supporting power? In the case of which curve is this most important?

(12) Why not hold the trunk erect in fallout positions ?

(13) Why is sitting position more favorable for taking exercise for the abdominal muscles than standing position?

(14) Why does round shoulders tend to cause hollow back?

(15) Why does standing on one foot cause lateral curvature of the spine?

(16) Why does lateral curvature always cause rotation of the spine in the region of the curve?

(17) Why do corsets and shoulder braces tend to cause bad posture?

(18) Why are standing and sitting more conductive to bad posture than walking?

(19) In what positions of the body does gravitation tend to straighten the spine?

(20) In trunk bending sidewise to right, what muscles act? In raising to position again?

ANTERIOR MUSCLES OF THE NECK.

1. *Sterno-cleido-mastoid.*

Origin,—the upper part of sternum and inner fourth of clavicle.

Insertion,—mastoid process of skull.

Structure,—longitudinal fibers, separating below into two parts.

Action,—when both muscles act, to flex the neck. When one acts alone, to flex it laterally and rotate the face to the opposite side.

2. *The Scaleni.*

These are three muscles on each side, all closely related.

Origin,—the anterior and middle scaleni, from the first rib. The posterior, from the second rib.

Insertion,—the sides of the cervical vertebrae, from the third downward.

Structure,—longitudinal, slightly converging fibers.

Action,—the muscles of one side acting, to flex the neck laterally.

QUESTIONS AND EXERCISES.

(1) Test strength of flexors of neck.

(2) Of extensors.

(3) Of lateral flexors.

(4) Analyze: body straight, horizontal, face down, weight on hands and toes.

(5) Body straight, horizontal, face up, weight on neck and heels.

(6) Body straight, horizontal, face up, weight on lumbar region.

(7) Body straight, horizontal, face down, weight on abdomen.

(8) What muscles turn face and trunk to left while sitting?

(9) Analyze vault over horse between pommels

II. ARTICULATIONS OF RIBS.

(a) With the bodies of the vertebrae.

(b) With the transverse processes. These are arthrodial joints.

Ligaments,—there is a capsular ligament surrounding each articulation, and several small ligaments binding the bones together.

Movements,—a slight gliding movement at each place, that at the end of the rib being a rotatory movement and at the transverse process a vertical one.

(c) With the costal cartilages. Here we have arthrodial joints, the end of each costal cartilage fitting into a cup-shaped cavity in the end of its rib, and bound with ligaments. The costal cartilages are themselves capable of some elastic movement, and they are attached to the sternum by arthrodial joints.

MOVEMENTS OF THE RIBS.

1. A movement of elevation or depression of the ribs and sternum upon the vertebral ends of the ribs as centers.
2. A vertical movement of each at its middle, upon both ends as centers.

MUSCLES OF RESPIRATION.

1. *External Intercostals.*

Origin,—lower border of all the ribs except the last, extending the whole length of the ribs, but not to the cartilages.

Insertion,—upper border of all the ribs except the first.

Structure,—parallel fibers, extending downward and inward, in the direction of the fibers of the external oblique.

Action,—to raise the ribs.

2. *Internal Intercostals.*

Origin and insertion,—same as the preceding, except that the muscle lies beneath it and extends from the angles of the ribs to the sternum.

Structure,—parallel fibers extending downward and outward, or in the direction of the fibers of the internal oblique.

Action,—to raise the ribs. The action of these two muscles has been in dispute for centuries, but the latest investigators favor the view given. The slanting arrangement permits of greater range of movement than would be possible with one muscle. (See Morris, pages 304 and 417, also Duchenne.)

3. *Diaphragm.*

Origin,—a circular one, passing entirely around the interior of the body cavity, the attachment being to lumbar fascia, cartilages of lower six ribs and ensiform cartilage.

Insertion,—central tendon.

Structure,—the fibers are fleshy at their origin, and at first pass directly upward, then turn inward to the central tennon.

Action,—to depress the central tendon, and thus enlarge the chest cavity. In so doing the abdominal viscera are pushed downward, and the abdominal walls are stretched. The lower ribs are slightly elevated and moved outward by the contraction of the diaghragm,

4. *Serratus Posticus Superior.*

Origin,—spines of lower cervical and upper thoracic vertebraes.

Insertion,—upper borders of ribs from second to fifth, external to their angles.

Structure,—tendonous origin, fleshy insertion, fibers passing diagonally downward and outward.

Action,—to raise the ribs.

Besides these muscles, which act during ordinary breathing, the scaleni, trapezius, sterno-mastoid, and the pectoralis minor act in forced inspiration, as in violent exercise or voluntary deep breathing.

Expiration is ordinarily produced by the elasticity of the ligaments and other tissues of the chest and abdominal walls. In forced expiration the serratus posticus inferior, triangularis sterni, ilio costalis, and abdominal muscles act to compress the chest cavity.

QUESTIONS AND EXERCISES.

(1) Test the inspiratory muscles of the chest with the dynamometer.

(2) Test the expansion of the waist in inspiration with the dynamometer.

(3) What muscles do the work in each case?

(4) What effect has arm raising upon chest expansion ?

(5) Of overhead pulley? of ring work?

(6) Why does work on the bars and rings interrupt breathing?

(7) What has the posture of the cervical spine have to do with breathing?

(8) Of the thoracic spine?

(9) Test the breathing muscles with the spirometer. What muscles are used in this test and not used in the test wish dynamometer?

(10) Trace the alimentary canal and identify its various parts on the manikin.

BIBLIOGRAPHY.

(For periodical literaure consult department card catalogue.)

Alumni of B. N. S. G.—100 Gymnastic Games.

Anderson, W. G.—(1) Light Gymnastics.
(2) Methods of Teaching Gymnastics.

Ballin, Hans.—Gymnastics in the Schoolroom.

Bancroft, Jessie H.—School Gymnastics.

Barwell, Richard.—Lateral Curvature of the Spine.

Betz, Carl.—Public School Course in Gymnastics. 3 Vols.

Bowditch, H. P.—The Growth of Children. (In Papers on Anthropometry).

Boykin, Jas. C.—History of Physical Training. (Report of Commissioner of Education for 1891-2, Vol, I, p- 451.

Camp, Walter.—Book of College Sports.

Cassell.—Book of Sports and Pastimes.

Doty, A. H.—Prompt Aid to the Injured.

Duchenne, G. B.—Physiologie des Mouvements.

Enebuske, C. J.—Progressive Gymnastic Days' Orders.

Foster, M.—Text-Book of Physiology.

Galton, Sir Francis.—Natural Inheritance.

Gray, Henry.—Anatomy, Descriptive and Surgical.

Gulick, Luther.—Manual for Physical Measurements.

Hartwell, E. M.—(1) History of Physical Training. (Bureau of Education, No. 5.)
—(2) Seats and Desks. (Report of Phys. Train., in Boston, 1894.)

Harvey, T. J.—Teachers' Manual of Physical Exercises.

Howell, W. H.—An American Text-Book of Physiology.

Klein, E.—Elements of Histology.

Lagrange, Ferdinand.—(1) Physiology of Exercise.
(2) Medication par L'Exercise.

Lewis, Percy G.—Early Scoliosis.

Landois and Stirling.—Human Physiology.

Marey, E. J.—Le Mouvement.

Martin, H. N.—The Human Body.

Mills, W.—Animal Physiology.

Morris, Henry.—Human Anatomy.

Mosso, A.—Fatigue.

Müller, Geo.—Spinal Curvature and Awkward Deportment.

Nissen, H.— A-B-C of Swedish Gymnastics.

Oppenheim, Nathan.—The Development of the Child.

Page, R. C. M.—Physical Diagnosis.

Piersol, Geo. A.—Normal Histology.

Pitcher, Jas. E.—First Aid in Illness and Injury.

Porter, W. T.—The Growth of St. Louis School Children. (Papers on Anthropometry.)

Posse, Baron Nils.—(1) Handbook of School Gymnastics.
(2) The Swedish System of Educational Gymnastics.
(3) Special Kinesiology of Educational Gymnastics.

Rettger, Louis J.—Studies in Advanced Physiology.

Schmidt, F. A.—Physical Exercises and their Beneficial Influence.

Seaver, Jay W.—Anthropometry and Physical Examination.

Stecher, W. A.—German American Gymnastics.

Stephenson and Murphy.—A Treatise on Hygiene and Public Health.

Stöhr, Philip.—Text-Book of Histology.

Strachan, John.—What is Play?

Suder, Henry.—Teachers' Manuals of Physical Culture.

Tsanoff, S. V.—Educational Value of Children's Playgrounds.

U. S. Infantry Drill Regulations.

Vierordt, Oswald.—Medical Diagnosis.

Waller, A. D.—Human Physiology.

Young, A. G.—School Hygiene. (Maine Health Report, 1891.)

Young Folk's Cyclopedia of Games and Sports.

Y. M. C. A. Athletic League.—Handbook of Athletic Rules and Scoring Tables.

A LIST OF BOOKS

PUBLISHED BY

GEO. WAHR

PUBLISHER AND BOOKSELLER TO THE UNIVERSITY OF MICHIGAN,
ANN ARBOR.

Any book in this list will be sent, carriage free, to any address in the world on receipt of price named.

BOWEN.—*A Teachers' Course in Physical Training.* By Wilbur P. Bowen, Director of Physical Training, Michigan State Normal College. In Press.

CHEEVER.—*Select Methods in Inorganic Quantitative Analysis.* By Byron W. Cheever, A.M., M.D., late Acting Professor of Metallurgy in the University of Michigan. Revised and enlarged by Frank Clemes Smith, Professor of Geology, Mining and Metallurgy in the State School of Mines, Rapid City, S. D. Parts I. and II. Third edition, 12mo, $1.75.

The first part of this book, as indicated by the title, consists of Laboratory Notes for a Beginner's Course in Quantitative Analysis. It considers the subjects of Gravimetric and Volumetric Analysis, for beginners, by means of the chemical analysis of a set of substances, properly numbered, in each case giving the methods to be followed in such analysis; also the methods for calculating and preparing volumetric standard solutions, generally following the course offered by Professor Cheever to his students. It also considers the methods for the determination of the specific gravities of various liquids and solids.

Although a number of the analyses contained in Part I. may be of only approximate accuracy, and of small commercial value, such are yet included with a special purpose, to wit:—that they may supply the student with a wider range of work and a greater diversity of chemical manipulation. This was Professor Cheever's idea, and it is certainly a good one, especially since, in most cases, the work of the beginner simply serves to emphasize the necessity of careful scrutiny of details and methods for practical work in the future.

Part I. is offered, then, for the use of schools and colleges, and it is intended to supply a source of elementary information upon the subject of Quantitative Chemical Analysis rarely offered in such form in works upon that subject.—Preface.

The author was for many years Professor of Metallurgy in the University of Michigan, and the methods here presented are those mostly offered by him to his students. As a beginner's book in quantitative analysis, it will be found eminently practical, and it can be honestly recommended to the student who desires a source of elementary information upon this branch of applied science. The book is divided into two parts, the first consisting of laboratory notes for beginners. The subjects of gravimetric and volumetric analysis are considered by means of the chemical analysis of a set of substances, properly numbered, in each case giving the methods to be followed in such analysis, and also the methods of calculating and preparing volumetric standard solutions, etc. Methods for the determination of specific gravities of various liquids and solids are also considered.

Part II. contains a number of select methods in inorganic quantitative analysis, such as the analysis of limestone, iron ores, manganese ores, steel, the analysis of coal, water, mineral phosphates, smelting ores, lead slags, copper, arsenic, bismuth, etc. A chapter on reagents concludes the work.—*Pharmaceutical Era.*

DEWEY.—*The Study of Ethics. A Syllabus.* By John Dewey, Professor of Philosophy in the University of Chicago. Octavo. 144 pages. Cloth, $1.25.

D'OOGE.—*Helps to the Study of Classical Mythology; for the Lower Grades and Secondary Schools.* By B. L. D'Ooge, Professor in the Michigan State Normal College. 12mo. 180 pages. Cloth. 45 cents.

A bibliography based on practical experience. The author is a professor in the Michigan State Normal College. As the myths of all nations manifest themselves first in religion, secondly in art, and third in literature, these reading references are grouped in the above classes. One section is devoted to the study of mythology in the grades, and an introductory chapter gives hints for teaching the subject in the lower grades. The books suggested in the body of the work are given in one alphabet at the end, with publishers and prices; there are also blank pages for additional references, and a good general index.—*Publishers Weekly,*

DOW.—*Brief Outlines in European History. A Syllabus for the Use of Students in History, Course I., in the University of Michigan.* By Earl Wilbur Dow. 41 pages. Pamphlet, 35 cents.

DOW.—*Brief Outlines in European History. A Syllabus for the Use of Students in History, Course II., in the University of Michigan.* By Earl Wilbur Dow. 47 pages. Pamphlet, 35 cents.

DZIOBEK.—*Mathematical Theories of Planetary Motions.* By Dr. Otto Dziobek, Privatdocent in the Royal Technical High School of Berlin, Charlottenburg. Translated by Mark W. Harrington, formerly Chief of the United States Weather Bureau, and Professor of Astronomy and Director of the Observatory at the the University of Michigan, President of the University of Washington, and Wm. J. Hussey, Assistant Professor of Astronomy in the Leland Stanford, Jr. University. 8vo. 294 pages. $3.50.

The determination of the motions of the heavenly bodies is an important problem in and for itself, and also on account of the influence it has exerted on the development of mathematics. It has engaged the attention of the greatest mathematicians, and, in the course of their not altogether successful attempts to solve it, they have displayed unsurpassed ingenuity. The methods devised by them have proved useful, not only in this problem, but have also largely determined the course of advance in other branches of mathematics. Analytical mechanics, beginning with Newton, and receiving a finished clearness from Lagrange, is especially indebted to this problem, and in turn, analytical mechanics has been so suggestive in method as to determine largely both the direction and rapidity of the advancement of mathematical science.

Hence, when it is desired to illustrate the abstract theories of analytical mechanics, the profundity of the mathematics of the problem of the motions of the heavenly bodies, its powerful influence on the historical development of this science and finally the dignity of its object, all point to it as most suitable for this purpose.

This work is intended not merely as an introduction to the special study of astronomy, but rather for the student of mathematics who desires an insight into the creations of his masters in this field. The lack of a text-book, giving, within moderate limits and in a strictly scientific manner, the principles of mathematical astronomy in their present remarkably simple and lucid form, is undoubtedly the reason why so many mathematicians extend their knowledge of the solar system but little beyond Kepler's law. The author has endeavored to meet this need, and at the same time to produce a book which shall be so near the present state of the science as to include recent investigations and to indicate unsettled questions.

FORD.—*The Cranial Nerves.* 12 pairs. By C. L. Ford, M.D., late Professor of Anatomy and Physiology in University of Michigan. Chart, 25 cents.

FORD.—*Classification of the Most Important Muscles of the Human Body, With Origin Insertion, Nervous Supply and Principal Action of Each.* By C. L. Ford, M.D., late Professor of Anatomy and Physiology in the University of Michigan. Chart, 50 cents.

FRANCOIS.—*Les Aventures Du Dernier Abencerage Par Chateaubriand, Edited with Notes and Vocabulary.* By Victor E. Francois, Instructor in French in the University of Michigan. Pamphlet, 35 cents.

GRAY.—*Outline of Anatomy. A Guide to the Dissection of the Human Body, Based on Gray's Anatomy.* 54 pages. Boards, 60 cents.

The objects of the outline are to inform the students what structures are found in each region and where the description of each structure is found in Gray's Anatomy.—Thirteenth edition, dated 1897.

GREENE.—*The Action of Materials Under Stress, or Structural Mechanics.* With examples and problems. By Charles E. Greene, A.M., M.E., Professor of Civil Engineering in the University of Michigan. Consulting Engineer. Octavo. Cloth, $3.00.

Contents.—Action of a Piece under Direct Force. Materials. Beams. Torsion. Moments of Inertia. Flexure and Deflection of Simple Beams. Restrained Beams: Continuous Beams. Pieces under Tension. Compression Pieces:—Columns, Posts and Struts. Safe Working Stresses. Internal Stress: Change of Form. Rivets: Pins. Envelopes: Boilers, Pipes, Dome. Plate Girder. Earth Pressure: Retaining Wall: Springs: Plates. Details in Wood and Iron.

HERDMAN-NAGLER.—*A Laboratory Manual of Electrotherapeutics.* By William James Herdman, Ph.B., M.D., Professor of Diseases of the Nervous System and Electrotherapeutics, University of Michigan, and Frank W. Nagler, B.S., Instructor in Electrotherapeutics, University of Michigan. Octavo. Cloth. 163 pages. 55 illustrations. $1.50.

It has been our experience that the knowledge required by the student of medicine concerning electricity and its relation to animal economy is best acquired by the laboratory method. By that method of instruction each principle is impressed upon the mind through several separate paths of the sense perception and a manual dexterity is acquired which is essential to success in the therapeutic applications.

This has been the plan adopted for teaching electrotherapeutics at the University of Michigan. Every form of electric modality that has any distinctive physiological or therapeutical effect is studied in the laboratory as to its methods of generation, control and application to the pattent. We believe this to be the only practicable way for imparting the kind of instruction required for the practice of electrotherapeutics, but in our attempt to develop a naturally progressive and at the same time complete and consistent course of laboratory instruction we have found it a thing of slow growth.

This laboratory manual is the final result of our various trials and experiences, and while we do not claim for it either perfection in the arrangement of matter or completeness in detail, we feel that the time has come for putting our plans in a form that will permit for it a wider usefulness as well as gain for it in the intelligent criticism of the experienced workers to the field which it seeks to cultivate.—*From Preface.*

HOWELL.—*Directions for Laboratory Work in Physiology for the Use of Medical Classes.* By W. H. Howell, Ph.D., M.D., Professor of Physiology and Histology. Pamphlet. 62 pages. 65 cents.

HUBER.—*Directions for Work in the Histological Laboratory.* By G. Carl Huber, M.D., Assistant Professor of Histology and Embryology, University of Michigan. Second edition, revised and enlarged. Octavo. 191 pages. Cloth, $1.50.

It is adapted for classes in medical schools and elsewhere where it is desired to furnish the class with material already prepared for the demonstration of structure rather than to give instruction in the technique of the laboratory. Provision for the latter is made, however, by the addition of a section of about 50 pages on the methods for laboratory work. This section includes methods of macerating, hardening and fixing, decalcifying, impregnation, injecting, embedding, staining, and methods for preparing and staining blood preparations. The last is accompanied by an excellent plate of blood elements. The selection of methods has in the main been judicious. The expositions are both clear and concise.—*Journal of Comparative Neurology.*

In this little book Dr. Huber has given us a model manual of microscopical technique in the laboratory study of histology. The subject matter is divided into convenient chapters, commencing with the cell and cell division (karyokinesis) in plant and animal life, and gradually developing, by easy stages, the most complex tissues of the animal and vegeatble organism. Between each lesson blank pages are interleaved, to be used by the student for drawing the objects seen by him with a pencil or crayon—a most excellent plan as nothing fixes the appearance and characteristics of objects more firmly on the mind than drawing them, either free-hand or with a camraa lucida (the former being preferable, as it educates the hand and eye). With each subject is given the source and origin, the best methods for obtaining and preparing it, and attention is called to the most noteworthy or characteristic points for examination.

The seoond part of the book is devoted to methods for laboratory work: softening, hardening, decalcification, etc., of the matter in gross; embedding, sectioning, staining and mounting, etc. The best stains, with methods of preparing the same, and, in short, a general formulary for the various reagents, etc., concludes the work, which is intended, as stated, as an *aide memoire* supplementary to a course of lectures on histology.

We congratulate Dr. Huber on the skill with which he has developed the idea, and the didactic methods which he has employed. Such a book cannot but prove a great help to both student and teacher, and it should be more widely known —*St. Louis Medical and Surgeon's Journal.*

JOHNSON.—*Elements of the Law of Negotiable Contracts.* By E. F. Johnson, B.S., LL.M., Professor of Law in the Department of Law of the University of Michigan. 8vo., 735 pages. Full law sheep binding. $3.75.

Several years of experience as an instructor has taught the author that the best method of impressing a principle upon the mind of the student is to show him a practical application of it. To remember abstract propositions, without knowing their application, is indeed difficult for the average student. But when the primary principle is once associated in his mind with particular facts illustrating its application, it is more easily retained and more rapidly applied to analogous cases.

It is deemed advisable that the student in the law should be required, during his course, to master in connection with each general branch of the law, a few well-selected cases which are illustrative of the philosophy of that subject. To require each student to do this in the larger law schools has been found to be impracticable, owing to a lack of a sufficient number of copies of individual cases. The only solution of this difficulty seems to be to place in the hands of each student a volume containing the desired cases. In the table of cases will be found many leading cases printed in black type.—*From Preface.*

LEVI-FRANCOIS.—*A French Reader for Beginners, with Notes ana Vocabulary.* By Moritz Levi, Assistant Professor of French, University of Michigan, and Victor E. Francois, Instructor in French, University of Michigan. 12 mo. 261 pages. $1.00.

This reader differs from its numerous predecessors in several respects. First, being aware that students and teachers in the French as well as in the German departments of high schools and colleges are becoming tired of translating over and over again the same old fairy tales, the editors have avoided them and selected some interesting and easy short stories. They have also suppressed the poetic selections which are never translated in the class room. Finally, they have exercised the greatest care in the gradation of the passages chosen and in the preparation of the vocabulary, every French word being followed not only by its primitive or ordinary meaning, but also by the different English equivalents which the text requires. After careful examination, we consider this reader as one of the best on the American market.

LLOYD.—*Philosophy of History. An Introduction to the Philosophical Study of Politics.* By Alfred H. Lloyd, author of Citizenship and Salvation, and Dynamic of Idealism. In press.

LYMAN-HALL-GODDARD.—*Algebra.* By Elmer A. Lyman, A.B., Edwin C. Goddard, Ph.B., and Arthur G. Hall, B.S., Instructor in Mathematics, University of Michigan. Octavo. 75 pages. Cloth, 90 cents.

MATTHEWS.—*Syllabus of Lectures on Pharmacology and Therapeutics in the University of Michigan. Arranged Especially for the Use of the Classes Taking the Work in Pharmacology and Therapeutics at the University of Michigan.* By S. A. Matthews, M.D., Assistant in Pharmacy and Therapeutics, University of Michigan. 12mo. 114 pages. $1.00.

MEADER.—*Chronological Outline of Roman Literature.* By C. L Meader, A.B., Instructor in Latin in University of Michigan. Chart, 25 cents.

MICHIGAN BOOK.—*The U. of M. Book. A Record of Student Life and Student Organizations in the University of Michigan.* Articles contributed by members of the Faculty and by prominent Alumni. $1.50.

MONTGOMERY-SMITH.—*Laboratory Manual of Elementary Chemistry.* By Jabez Montgomery, Ph.D., Professor of Natural Science, Ann Arbor High School, and Roy B. Smith, Assistant Professor in Chemical Laboratory, Ann Arbor High School. 12 mo. 150 pages. Cloth, $1.00.

This Work is intended as a laboratory guide to be used in connection with a good text-book or course of lectures, and in its arrangement and scope it is based upon the practical experience of two instructors in the Ann Arbor High School. It is therefore restricted to such work as may be done by the average high school pupil. The experiments which are directed are given more to enable the student to comprehend the methods of analytical chemistry than to acquire particular proficiency in the work of chemical analysis. The work is characterized by minuteness of explanation, a feature which will be appreciated by the beginner.—*Pharmaceutical Era.*

NETTO.—*The Theory of Substitutions and its Application to Algebra.* By Dr. Eugene Netto, Professor of Mathematics in the University of Giessen. Revised by the author and translated with his permission, by F. N. Cole, Ph.D., formerly Assistant Professor of Mathematics in the University of Michigan, Professor of Mathematics, Columbia University. 8 vo. 301 pages. Cloth. $3.00.

NOVY.—*Laboratory Work in Physiological Chemistry.* By Frederick G. Novy, Sc.D., M.D., Junior Professor of Hygiene and Physiological Chemistry, University of Michigan. Second edition, revised and enlarged. With frontispiece and 24 illustrations. Octavo. Cloth, $2.00.

This book is designed for directing laboratory work of medical students, and in showing them how to study the physics and physiology of the digestive functions of the blood, the urine and other substances which the body contains normally, or which it speedily eliminates as effete material. The second edition has appeared within a very short time after the publication of the first. The first chapters deal with the facts, the carbohydrates and proteids. Then follow others upon the saliva, the gastric juice, the pancreatic secretion, the bile, blood, milk, and urine, while the closing chapter deals with a list of reagents.

While the book is manifestly designed for the use of Dr. Novy's own students, we doubt not that other teachers will find it a valuable aid in their work. At the close of the volume are a number of illustrations of the various sedimentary substances found in the urine, taken from the work of von Jaksch.—*The Therapeutic Gazette*

This book, although now in its second edition, is practically unknown to British readers. Up to the present, anyone wishing to find out how a particular analytical method in physiological chemistry ought to be carried out, had of necessity to refer to a German text-book. This comparatively small book—for it only covers some three hundred pages—gives as good a general account of ordinary laboratory methods as any teacher or student could desire. Although the author refers in his preface to help derived from the works of Salkowski, Hammarsten and others, it is but fair to say that the book has undoubtedly been written by one who has worked out the methods and knows the importance of exact practical details—***Edinburgh Med. Jour.***, Scotland.

Physiological chemistry is one of the most important studies of the medical curriculum. The cultivation of this field has until recently been possible to but few. The rapid development of this department of science within a few years past has thrown much and needed light upon physiological processes. It is from this quarter and from bacteriological investigations that progress must chiefly be expected. The rapid growth of this branch of chemistry is attended by another result. It necessitates the frequent revision of text-books. The present edition of Dr. Novy's valuable book is almost wholly rewritten It is representative of the present state of knowledge and is replete with information of value alike to student and practitioner. Few are better prepared to write such a book than Dr. Novy, who has himself done much original work in this field.—***The Medical Bulletin, Philadelphia.***

This is a greatly enlarged edition of Dr. Novy's work on Physiological Chemistry, and contains a large amount of new material not found in the former edition. It is designed as a text-book and guide for students in experimental work in the laboratory, and does not therefore cover the same ground as the works of Gamgee, Lea, and other authors of books on physiological chemistry. As a laboratory guide it should be adopted by our medical colleges throughout the country, because it is an American production, contains only such directions and descriptions as have been verified by actual practice with students, and because it is clear, concise and definite in all its statements. Its first ten chapters treat of fats, carbohydrates, proteins, saliva, gastric juice pancreatic secretion, bile, blood, milk, and urine. Chapter xi. is devoted to the quantitative analysis of urine, milk, gastric juice, and blood, while chapter xii. gives tables for examination of urine and a list of reagents.—***Am. Medico-Surgical Bulletin, N. Y.***

NOVY.—*Laboratory Work in Bacteriology.* By Frederick G. Novy, Sc. D., M.D., Junior Professor of Hygiene and Physiological Chemistry, University of Michigan. Second edition, entirely rewritten and enlarged, 563 pages. Octavo. $3.00.

As a teacher of bacteriology, the author has had extensive experience, and the second edition of his book will be highly prized by students for its practical service and thoroughness. The methods of investigation described are mainly those which have been employed in the hygienic laboratory or the University of Michigan, and they have stood the test of practical demonstration and usefulness. One of the most interesting parts of the book is the chapter on the chemistry of bacteria, and the general reader cannot fail to obtain from it a clear understanding of the complex changes induced by these minute organisms. The functions of the various ferments are also very cleverly discussed. An enumeration of the chapter headings will serve to show the scope of the work: Form and Classification of Bacteria; Size and Structure of Bacterial Cell; Life History of Bacteria; Environment of Bacteria; Chemistry of Bacteria; the Microscope; Cultivation of Bacteria; Non-Pathogenic Bacteria; Bouillon, Agar, Milk and Modified Media, the Incubator and Accessories; Relation of Bacteria to Disease—Methods of Infection and Examination; Pathogenic Bacteria; Yeasts, Moulds and Streptotrices; Examination of Water, Soil and Air; Special Methods of Work. To the latter subject, two chapters are devoted. in which are very fully outlined various special methods of value to advanced students.—***Pharmaceutical Era, N. Y.***

STRUMPELL.—*Short Guide for the Clinical Examination of Patients.* Compiled for the Practical Students of the Clinic, by Professor Dr. Adolf Strümpell, Director of the Medical Clinic in Erlangen. Translated by permission from the third German edition, by Jos. L. Abt. Cloth, 39 pages, 35 cents.

PREFACE TO THE SECOND EDITION.—The second edition of this book has been improved by me in several parts, and particularly the sections treating of the examination of the stomach and nervous system have been slightly extended. The author trusts that the book may also fulfill its purpose in the future, in assisting the student to learn a systematic examination of the patient, and to impress on him the most important requisite means and methods.

SUNDERLAND.—*One Upward Look Each Day. Poems of Hope and Faith.* Selected by J. T. Sunderland. Third Edition, 16 mo. White Binding, 30 cents; Cloth, 40 cents; Full morocco, 75 cents.

SUNDERLAND—*Grains of Gold. Some Thoughts and a Brief Prayer For Each Day of the Months. Designed as Daily Helps in the Higher Life.* Compiled by J. T. Sunderland. White Binding, 35 cents.

WARTHIN.—*Practical Pathology for Students and Physicians. A Manual of Laboratory and Post-Mortem Technic, Designed Especially for the Use of Junior and Senior Students in Pathology at the University of Michigan.* By Aldred Scott Warthin, Ph.D., M. D., Instructor in Pathology, University of Michigan. Octavo. 234 pages. Cloth, $1.50.

We have carefully examined this book, and our advice to every student and practitioner of medicine is—buy it. You will never regret having invested your money in it, and you will acquire such a large fund of information that the study of pathology will become a pleasure instead of the drudgery which it so unfortunately seems to be in many cases.

Part I. of this book, embracing some 103 pages, deals with the materials, which includes the proper examination and notation of the gross changes which have occurred in every part of the body. In fact it is a complete exposé of what a complete and accurate autopsy should be, the observance of which is oftener followed in the breach than in the actuality. Part II., which includes 134 pages, deals with the treatment of the material. This is a very important part of the work, as it gives explicit directions in regard to the instruments to use, stains and staining methods, drawing, the preservation of specimens, hardening methods, in fact, of all those technical points connected with practical pathological microscopy. The examination of fresh specimens, injections, methods fixing specimens as well as special staining methods are taken up. In fact, space forbids us to give the entire, which are most valuable in every detail.—*St. Louis Medical and Surgical Journal.*

WATSON.—*Tables for the Calculation of Simple or Compound Interest and Discount and the Averaging of Accounts. The Values of Annuities, Leases, Interest in Estates and the Accumulations and Values of Investments at Simple or Compound Interest for all Rates and Periods; also Tables for the Conversion of Securities and Value of Stocks and Bonds. With full Explanation for Use.* By James C. Watson, Ph.D., LL.D. Quarto. Cloth, $2.50.

A book most valuable to bankers, brokers, trustees, guardians, judges, lawyers, accountants, and all concerned in the computation of interest, the division and setlement of estates, the negotiation of securities, or the borrowing and lending of money, is the above work of the late Professor James C. Watson, formerly Director of the Observatories and Professor of Astronomy at the Universities of Michigan and Wisconsin, and Actuary of the Michigan Mutual Life Insurance Company.

It contains, in addition to the usual tables for the calculation of simple or compound interest and discount, many tables of remarkable value, not found elsewhere, for the averaging of accoutns, the values of annuities, leases, interests in estates, and the accumulations and values of investments; also tables for the conversion of securities, and the values of stocks and bonds.

There are also given very full and clear explanations of the principles involved in financial transactions, and a great variety of miscellaneous examples are worked out in detail to illustrate the problems arising in interest, discount, partial payments, averaging of accounts, present values, annuities of different kinds, annual payments for a future expectation (as in life insurance), or for a sinking fund, conversion of securities, values of stocks and bonds, and life interests.

This book was issued from the press under the author's careful supervision. Professor Watson was noted for his clear insight into problems involving computations, and also for his wonderful ability in presenting the method of solution of such problems in a plain and simple manner. The varied array of practical examples given in connection with his "Table" shows these facts in a remarkable manner. This book provides, for those least expert in calculations, the means of avoiding mistakes likely to occur; and for the man engrossed in the cares of business, the means of making for himself, with entire accuracy, the calculation which he may need. at the moment when it is needed.

WRENTMORE-GOULDING.—*A Text-Book of Elementary Mechanical Drawing for Use in Office or School.* By Clarence G. Wrentmore, B.S., C.E., and Herbert J. Goulding, B.S., M.E., Instructors in Descriptive Geometry and Drawing at the University of Michigan. Quarto. 109 pages and 165 cuts. $1.00.

This book is intended for a beginners course in Elementary Mechanical Drawing for the office and school. Illustrations have not been spared, and the explanations have been made in a clear and concise manner for the purpose of bringing the student to the desired results by the shortest route consistent with the imparting of an accurate knowledge of the subject.

The first chapter is devoted to Materials and Instruments; the second chapter, Mechanical Construction; third chapter, Penciling. Inking, Tinting; fourth chapter, Linear Perspective; fifth chapter, Teeth of Grass.

WRENTMORE.—*Plain Alphabets for Office and School.* Selected by C. G. Wrentmore, B.S., C.E., Instructor in Descriptive Geometry and Drawing, University of Michigan. Oblong. 19 plates. Half leather, 75 cents.

Souvenir of the University of Michigan, Ann Arbor. Containing 38 photo-gravures of President James B. Angell, prominent University Buildings, Fraternity Houses, Churches, Views of Ann Arbor, Etc., Etc. Done up in blue silk cloth binding. Price, 50 cents, postpaid.

Physical Laboratory Note Book.—*A Note Book for the Physical Laboratory.* Designed to be used in connection with Chute's Physical Laboratory Manual. Contains full directions for keeping a Physical Laboratory Note Book. 112 pages of excellent writing paper, ruled in cross sections, Metric System, size 7 x 9½ inches. Bound in full canvass, leather corners. Price, by mail, 30 cents. Special prices to Schools furnished on application.

Botanical Laboratory Note Book.—*A Note Book for the Botanical Laboratory.* Contains directions for Botanical Laboratory. 200 pages of best writing paper, ruled with top margins. Pocket on inside of front cover for drawing cards. Bound in substantial cloth cover and leather back. Size 6 x 9½. Price, by mail, 35 cents. Special prices to schools furnished on application.

GV341 .B62
A teachers' course in physical trai
Gutman Library AOV4402
3 2044 028 805 117